Addis Ababa University

School of Graduate Studies

College of Natural Sciences

Department of Computer Science

Telehealth Support System Using Wireless Technologies: The Case of Ethiopia

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Table of Contents

List of Tables

List of Figures

List of Acronyms

2G	Second Generation
3G	Third Generation
AIDS	Acquired Immune Deficiency Syndrome
APIs	Application Program Interfaces
BREW	Binary Run-time Environment for Wireless
CDC	Connected Device Configuration
CDMA	Code Division Multiple Access
CLDC	Connected Limited Device Configuration
CSA	Central Statistical Agency
DataTAC	Data Total Access Communications
DECT	Digital Enhanced Cordless Telecommunications
ETC	Ethiopian Telecommunication Corporation
EV-DO	Evolution-Data Optimized
FOM	Faculty of Medicine
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
GUI	Graphical User Interface
HIV	Human Immunodeficiency Virus
ICT	Information Communication Technology
iDEN	Integrated Digital Enhanced Network
J2EE	Java 2 Enterprise Edition
J2ME	Java 2 Micro Edition

J2SE	Java 2 Standard Edition
JAD	Java Application Descriptor
JAR	Java Archive
JSP	Java Server Pages
m-Health	Mobile Health
MIDP	Mobile Information Device Profile
MMS	Multimedia Messaging Service
MOH	Ministry of Health
SOA	Service Oriented Architecture
TDMA	Time Division Multiple Access
WAP	Wireless Application Protocol
W-CDMA	Wideband Code Division Multiple Access
WHO	World Health Organization
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network
VSAT	Very Small Aperture Terminal

Abstract

The explosion of wireless technologies including wireless networks, large flat displays, sensors, personal digital assistants (PDA), smart phones, and embedded devices are playing a great role in communication and service delivery of our daily life. Nowadays it is possible to extend different applications such as providing voice calls, remote consultation, remote discussion, remote health service, access different applications, and so on wirelessly to anywhere in the world over short or long distances.

In consideration of various advantages of wireless technologies, in this work we aim to explore the use of wireless technologies in health domain for remote health education. The main objective of this work is to design and implement a telehealth support system which helps to improve the quality of existing health system. The system allows the health professionals to have adequate access to patients, to medical information, to give health related services remotely, remote consultation, and remote education to patients/peoples anywhere and anytime.

The telehealth support system is developed using java programming language with J2ME CLDC/MIDP platform which ships with J2ME wireless toolkit emulator and MySQL database for data storage management.

Keywords: Telehealth, Telemedicine, Telecare, Health Education, Ethiopia, Wireless Technology.

Chapter 1: Introduction and Background

1.1 Introduction

The explosion of wireless technologies including wireless networks, touch panels, large flat displays, sensors, personal digital assistants (PDAs), cell-phones, and embedded devices have a potential to transform traditional habit of the way that we live. This enables people to communicate, to access applications, and to transfer information over short or very long distances without wires. This provides freedom of movement and the ability to extend applications to anywhere in the world. The term "wireless" most often refers to telecommunications [1]. Nowadays, it is uncommon to see the involvement of this wireless technology in various instances to facilitate different developments of human society. The involvement of wireless technology in health domain plays a pivotal role in improving provision of healthcare. This work explores the use of wireless technologies in medical applications for remote health education.

The use of wireless technology is on the rise in hospitals, medical offices, assisted living facilities and homes with a number of advantages over wired alternatives, created new possibilities known as telemedicine, telecare, and telehealth in healthcare fields [11]. Most of the time these three terms are used interchangeably, when in fact they are different depending on the coverage and application. Telemedicine specifically refers to medical information exchange over a distance using telecommunication technology [12]. Telecare refers to technology that allows patients at home to stay safe and healthy through the use of telecommunication technology [9].

Telehealth is the broad term which refers to providing healthcare services, health education, health management, and health information services over a distance via telecommunications technologies [5] and it is the expansion of telemedicine [2]. It allows remote doctor-patient consultation, remote monitoring of vital parameters, remote health education, teleconferencing between specialists, and enables practitioners to evaluate and diagnose patients remotely. Telehealth application offers an effective means of improving quality of health for any country especially for developing countries like Ethiopia which do have a number of health related problems and shortage of medical doctors and specialists. Therefore, due to the recent technological advances various researchers are interested to study the establishment and usage of wireless technologies as a vehicle for improving the quality of healthcare provision in healthcare fields.

Recent efforts include mobile technology to monitoring bio signal, follow-up patients, and advise patients on sexually transmitted infections respectively [12, 17, 18]. Others works focus on collecting, sharing and managing medical information as well as medical news based on different mechanisms like wirelessly using PDA, and using Service Oriented Architecture (SOA) [4, 6]. Some are also designed and implemented specifically on special area called cardiology/tele-cardiac [13, 15, 16]. However, the aforementioned existing systems and the other efforts [3, 19] are focused on achieving remarkable improvement in healthcare services specifically on curative aspect of the patients and less attention is given to health education on disease prevention and control, health management, and provision of health information services. The importance of health education on disease prevention and control is more effective than getting everyone sick and treating/following them individually. In consideration of this importance, in our proposed

work we will focus on health education, health management, and health information services of telehealth application.

Health education is a means to teaching and counseling of one or more peoples on proper way of healthy living in order to improve one's health. It can involve only one or two people, or the population of a country. By this people are able to learn how to prevent the spread of various kinds of diseases which can be categorized as communicable diseases, Sexually Transmitted Infections (STIs), non-communicable diseases, diet-deficiency diseases, and so on through the training and methods being taught in education. People are able to have better access to information regarding general prevention of diseases, including the knowledge of what to do and how to act during the increase of diseases. Therefore, in our work we will concentrate on proposing a generic telehealth support system using wireless technologies, which can enhance the existing healthcare applications by introducing remote health education on disease prevention (pre-disease), and disease control or reaction (post-disease) as well as enhance the provision of health information services to the public at large.

The system that we will propose provides a vehicle for doctors and patients in remote locations to interact, enable health professionals in distinct locations to share information as well as to monitor patients remotely and give them timely health information and support. The proposed system would even include a situation in which a doctor in one hospital can get/give support with a doctor somewhere in another hospital via digital imaging between professionals. Patient charts, X-rays, and other diagnostic materials can be transmitted digitally between doctor’s offices/smart devices. This potentially supports the extending of health information services available at anytime and anywhere.

1.2 Statement of the Problem

According to [21], the population number of Ethiopia is 96,633,458. Out of the total population, 85% live in rural areas, making Ethiopia one of the least urbanized countries in the world [20]. Rapid growth of population with a low ratio of health professionals exacerbates critical gaps in basic health services [14]. The healthcare system in Ethiopia can only be able to provide basic health services to 72% of the population [14]. The ratio of medical doctors to population is one of the lowest in the world 1:35,493 [51]. This is a big problem that affects the health of people in the country. Due to this a patient may suffer to the extent of losing of life.

The other health related problem is that resulting from lack of awareness and education. In most of the rural areas an estimate of 60-80% of the health problems is due to communicable and deficiency diseases which resulted from lack of awareness [8, 14]. Also the most common diseases that cause mortality among many Ethiopians are HIV/AIDS, tuberculosis, malaria, and various communicable diseases that occur due to improper sanitation and malnutrition [7]. In addition to this, due to poor transportation and other infrastructures in the country, it has been a challenging task to deliver health services and educate the rural people; also the health professionals may not be motivated to educate remote people. As a result the rural people have to travel long distances to get proper healthcare service. Their journey is difficult as the land is characterized by mountainous terrain and there is no adequate transportation. However, uniform healthcare coverage requires that healthcare be freely available to all citizens.

A solution to this problem is to effectively utilize the existing professionals and enhance the existing health system using wireless technologies. This provides a chance to make communication between health professionals and allowing them to have adequate access to patients, to medical information, to give health related services remotely, remote consultation,

and remote education to patients/peoples anywhere and anytime. It also enables patients to send video and high-resolution images between two distant locations, doctors can easily examine patients in offices thousands of miles away. As a result, rural patients do not need to make long trips to urban centers to get proper health services as well as to consult specialists. This helps a patient to save lots of time and money, provide ability to healthcare providers to save patient history and valuable information in their system. Hence telehealth application supported by modern wireless technologies allows medical specialists in the underserved areas to get specialist's support from other hospitals. The importance of this is not only for rural areas; it is also important for urban area as a means to communicate with advanced specialists as well as to get support from physicians living anywhere. To this reality there are many efforts done to establish the use of wireless technology as a vehicle to improve the health domain problems and to achieve aforementioned advantages. The gap in the existing work is that, they did not include telehealth education for diseases prevention and control. Therefore, our goal in the proposed system will be to achieving the aforementioned advantages of wireless technologies on health domain by incorporating health education for disease prevention and control which aimed to solve health related problems that can be resulted by lack of sufficient health professionals and lack of awareness on how to prevent the spread of diseases and how to control diseases in rural and/or urban areas in Ethiopia.

1.3 Objectives

General Objective

The general objective of this thesis is to design and implement a telehealth support system using wireless technologies.

Specific Objectives

In order to achieve the aforementioned general objective, this work has the following specific objectives;

- Identify the functional and non-functional requirements of the system.
- Design the system based on identified requirements.
- Develop a prototype by using appropriate programming languages to demonstrate the validity of the proposed system.

1.4 Methods

The different methods that we will use to design telehealth Support System at various phases are as follows:

- Conduct literature review: we will review and make assessment on different literature including books, research reports, journal articles and written documents.
- Data collection: in order to get various information about health and health education delivery, we will contact different stakeholders of the health providing systems in the country including Ministry of Health (MOH), Faculty of Medicine (FOM), and Ethiopian Public Health Institute. Also we will contact ethio telecom in order to know current status of telehealth services in Ethiopia.

1.5 Scope and Limitations

Health domain is one of a large application area of wireless technology which includes several applications that are done in telemedicine, telecare, and telehealth. From these telehealth is one of a broader term which can include several applications like healthcare service, health management, health education, health information services, and so on. However, this proposed

work focuses on health education, on disease prevention and disease control, and health information provision. In this work our scope is also limited to some of the chronic diseases such as STIs, communicable diseases and diet-deficiency diseases.

1.6 Application of Results

Health is one of the basic or critical things for human beings. Regarding to this, there are different organizations that provide health services. The MOH is one of the responsible organizations in Ethiopia which has a responsibility in controlling various health sectors like hospitals and clinics. So, in order to keep the quality of life of the population as well as to improve the delivery of health and health related services this system contributes a lot. As a result, MOH and various health centers, health professionals, and the like can improve the quality of health services. It also allows patients to get proper medical support.

1.7 Organization of Thesis

The rest of this thesis work is organized as follows: Chapter 2 discusses literature review. In Chapter 3, the details of various related works that are related to our work will be discussed. The analysis of the system is presented in Chapter 4. The design of the prototype and the architecture of the system are discussed in Chapter 5. Chapter 6 presents the tools and technologies that are used to implement the prototype as well as the result of the prototype. Finally, conclusions and future works are presented in Chapter 7.

Chapter 2: Literature Review

This literature review deals with the review of important concepts that are related to our work as well as used in this work in order to identify the existing techniques and analyze the current situations of the area. First, it provides background/general information on various wireless technologies and the use of wireless technology in the health domain. Secondly, some of telehealth related terms including health telematics, e-health, telecare, telemedicine, and telehealth will be discussed. Lastly, it provides information on the use/status of telemedicine/telehealth application in Ethiopia.

2.1 Wireless Technologies and their use in the Health Domain

In the healthcare settings, wireless transmission of information addresses convenience and portability. The range of wireless transmission varies from personal Area Network (PAN), Local Area Network (LAN), and Wide Area Network (WAN) for computer networks to Global System for Mobile Communication (GSM) for cellular networks. Other emergent data and multimedia wireless technologies include General Packet Radio Service (GPRS) and Evolution-Data Optimized (EV-DO) [22, 23].

Wireless PAN is primarily used in the monitoring of vital signs (i.e., temperature, heartbeat, blood pressure, and respiratory rate) [25]. It involves one or more sensors placed on a person's body that communicates wirelessly with a device that is capable of performing data collection, processing, and transmission. This device may also communicate with an external server for further processing and storage. It consists of a series of biosensors worn on a person's body that

communicate with a data acquisition module through the Bluetooth protocol. The data acquisition module forwards the collected data to a centralized server for further processing and analysis. The use of Bluetooth-enabled sensors eliminates the discomfort of tangling wires for patients. In comparison to Bluetooth, the ZigBee protocol requires lower power consumption, resulting in devices that are cheaper to manufacture and lighter to wear [24].

Wireless LAN allows multiple computing devices in a limited area to communicate among each other without physical cabling [26]. The data transmission rate of wireless LAN is superior to PAN [27]. In medical settings, transmission of complex data formats such as x-ray images or ECG in a wireless LAN is feasible.

The cellular system has evolved from purely a portable telephone system to an integrated platform for mobile voice in 1980s and advanced to data services in the 21st century. First generation (1G) cellular system used an analog signal transmission for voice [28]. It was replaced by second generation (2G) standards including CDMA, TDMA, and GSM. Its main difference from the previous generation is the inclusion of data services. For instance, the Wireless Application Protocol (WAP) allows users to access web pages and applications from their mobile phones and PDAs [37]. With the beginning of 2G standards, technologists saw an opportunity to use mobile devices to participate in the delivery of healthcare rather than merely serving as a means to contact physicians. Furthermore, data services such as short message service (SMS) and multimedia messaging service (MMS) allow patients and health professional to set up reminder and alert functions on their mobile wireless devices. Advances in data service technology such as GPRS (2.5G) and EV-DO (3G) are expected to provide more opportunities for health professional to deliver a better quality of care to patients.

2.2 Telehealth Related Terminologies

The efforts to embed advanced computing into the healthcare sector are today matched by efforts to utilize rapid developments in telecommunication. These could have the potential to revolutionize the healthcare system and support new ways of delivering care at a distance. Focusing on the possibilities and practice of remote delivery of healthcare services has led to the emergence of a specialist fields within the health domain such as health telematics, e-health, telecare, telemedicine, and telehealth. In this section some of these terms will be discussed.

Health Telematics

Telematics refers to the blending of computers and wireless communications technologies, apparently with the goal of efficiently conveying information over vast networks to improve a host of different public services [29]. According to World Health Organization (WHO), the general definition of health telematics is that: “Health-related activities, services and systems delivered over a distance by means of information and communication technologies” [30].

E-Health

The costs and benefits of telehealth will not be realized unless telehealth is perceived as an integral part of a larger domain, that of e-health [31]. With the relentless convergence of technologies and the consequent increase in our ability to perform multiple functions with those technologies, it is unwise to solely emphasize the distance factor the tele in telehealth. The term e-health was barely in use before 1999, yet now seems to encompass not only digital healthcare and Internet but virtually anything related to computers and healthcare [31]. It covers the use of

digital data transmitted electronically for clinical, educational and administrative applications, both face to face and at a distance.

Telecare

Another new term, Telecare is defined as "the delivery of health and social care to individuals in the home, with the support of devices enabled by information and communication technologies" [32]. Therefore it is concerned with the provision of care and community support to a patient at distance. Such provision of care includes: monitoring the daily living of individuals at risk, by connecting telecommunication to other premise that people should be able to participate in the community as much as possible [9]. This information can be delivered in a variety of ways including via the telephone (fixed or mobile), through the Internet or cable or satellite TV or via public information kiosks.

Telemedicine

The term telemedicine became prominent in the healthcare literature in the early 1960s [33]. The word was created by adding the prefix tele, ancient Greek for "distant" to medicine, i.e., quite literally "medicine practiced at a distance" [34]. It is used to describe a range of activities such as remote interactive healthcare consultations, provision of accident and emergency expertise, and remote monitoring [10]. It is now seen as a support tool to aid healthcare delivery, similar to the functionality offered by the fax machine or the stethoscope. The first telemedicine applications were developed in the late 1950s, when interactive video communications technology had limited capability. The result is that poor audio, poor imaging and poor reliability, using what was then very costly technology. Consequently there was very limited clinical interest in this emerging practice.

However, in the 1970s advancement in computing technology and higher processing speeds with the expansion of low-cost telecommunication technology provided another motivation in further telemedicine trials [34]. Rather than merely a skill substitution, telemedicine was seen as an opportunity to change medical practice radically to provide a seamless delivery of care, especially to remote and underserved communities. However, despite this promising future, hardly any of the first-generation telemedicine projects that is, those implemented prior to 1986 survived beyond the original grant funding cycle. It is claimed that such an outcome was not the result of a failure to achieve stated objectives. Rather, it was a consequence of a combination of factors such as the limitations of technology of the time and clinicians' and patients' unfamiliarity with it and limited experience in its use.

Telehealth

A recent trend noted in health domain is the prominence of the term telehealth, which now appears to be preferred over telemedicine when describing the generality of the practice of health service over a distance [2, 35]. Telehealth is especially favored in the importance of an overall multi-disciplinary/multi-professional approach to delivering health services rather than emphasizing the role of medical practitioners. Telehealth is the use of electronic information and telecommunication technologies including videoconferencing, store-forward imaging, and wireless communication. Due to this telehealth applications also incorporate heterogeneous technologies and services that cut across boundaries between different professionals including long distance healthcare services, education for patients and health professionals, public health promotion and administration, social services and information. Both telehealth and telemedicine can be offered using two modalities: real-time, and store-forward telehealth delivery [35].

Real-time telehealth uses videoconferencing technology consisting of audio and visual communication to contact the specialist and the patient as well as specialist to specialist [35]. The two parties interact with one another in real time. Store-and–forward type uses digital imaging of patients to represent a case [35]. Unlike real-time, store and forward telehealth services can be requested and reviewed at different times.

Generally, the request is generated either by health professionals or by patients. After receiving the request for health related services, the specialist generates information that is sent back to the requester based on his/her request. This would include a consult, health education on disease prevention and control, diagnosis, treatment, and management.

2.3 Telemedicine Application in Ethiopia

In the health domain, following the advancement of information and telecommunication technology, different efforts are made in the Ethiopian context to realize telemedicine in the nation. An attempt to introduce telemedicine started around 1997 when the Ethiopian Telecommunication Authority (ETA) recognized telemedicine as one of its services and Addis Ababa University Faculty of Medicine (AAUFOM) attempted to create awareness among stakeholders. To organize telemedicine efforts by these varying bodies, in February 1998, a National Telemedicine Coordinating Committee (NTCC) was established having members from the then Ethiopian Telecommunication Corporation (ETC), Ministry of Health (MOH), and AAUFOM [36, 3].

Following International Telecommunication Union's (ITU) commitment to support telemedicine pilot projects in developing countries, NTCC was prepared a project proposal and submitted it.

The project proposed connecting ten (one hospital as a central referral hospital) selected sites to the Internet. After 11 months of proposal submission and ITU's promise to provide material and expert support, a group of experts came to Ethiopia to visit selected sites and they recommended the implementation of the pilot project in the following three phases.

- *Phase I*: Pilot program, involves connecting ten sites.
- *Phase II*: Expanding the telemedicine network to more hospitals and health institutions in the country.
- *Phase III*: Expanding it further to join International Telemedicine Network.

The overall network diagram of the Ethiopian Telemedicine pilot project that connects the central referral hospital to 9 of rural sites is shown in Figure 2.1. In this pilot project, Tikur Anbessa Hospital is supposed to practice teleradiology and teledermatology, Gonder and Jimma university hospitals are supposed as specialty centers for Radiology consultation, and ALERT hospital for dermatologic consultation.

According to the conceptual network of the telemedicine network at that time when the pilot project was developed, all the ten sites have dialup Internet connection through the Public Switched Telephone Network (PSTN). However, as reported in [36], this pilot project stayed for one year practicing teleradiology and teledermatolgy in the above mentioned sites.

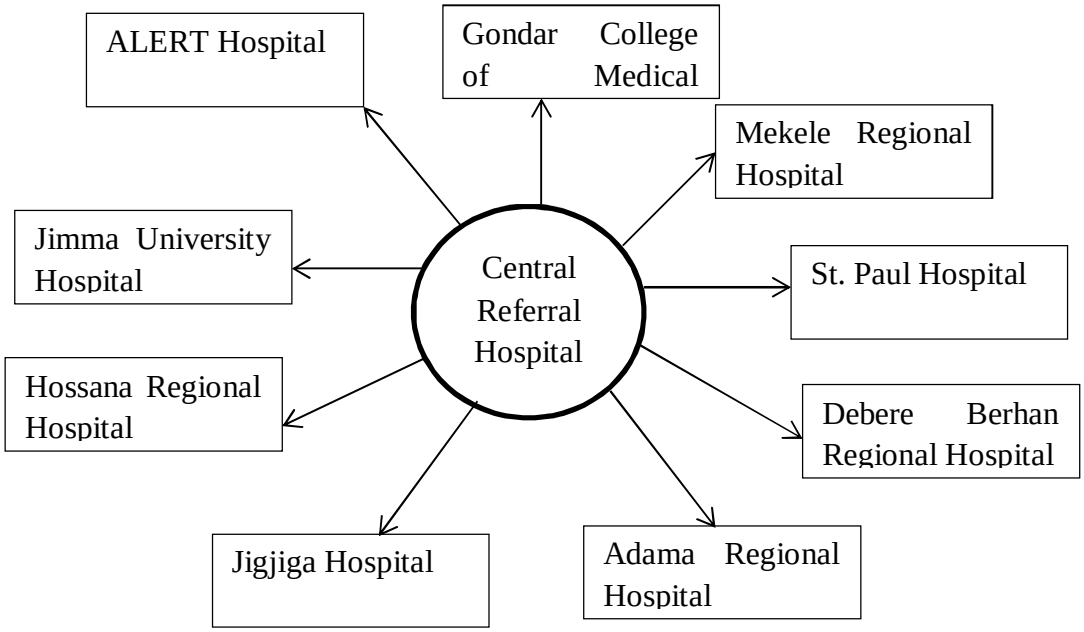


*Figure 2.1: Ethiopian Telemedicine Pilot Project System Network Diagram (*Source: [36]).

As reported by NTCC [36], during the trial phase of the pilot project the telemed software from WDS company worked for 28 days and expired and needs activation again. It is activated in five centers but still the software exhibited technical errors. Furthermore, they also list out, some of the drawbacks of the pilot project, i.e., some of the potential research gaps that affect quality of telemedicine services in the pilot project are as follows:

1. The software is not user friendly.
2. There is no system design that is planned for expansion of the system for future improvement.
3. It considers only the use of e-mail and file attachment.
4. It would be difficult to secure the patient information system.

In consideration of the aforementioned problems and some technical difficulties of telemed software, there was a need to develop new user friendly software which fits the improvement and development of future multipurpose use as well as uses wireless technology for its network connectivity.

Chapter 3: Related Work

Healthcare is a large and complex as well as expensive domain that aims at the delivery of cost-effective and quality health services to citizens. It deals with the prevention, treatment, and management of illness and the preservation of mental and physical wellbeing in human beings that are delivered by different health professionals [41]. In order to achieve this aim, various studies have been conducted to apply wireless technologies in healthcare domain to diverse healthcare related problems. This section presents the studies that are related to this thesis work. It also points out the limitations that make them not appropriate for slow and intermittent network connections. The major areas covered include telemedicine, telecare, and telehealth using wireless technologies.

Telemedicine Technology and Clinical Applications

For the last few decades, telehealth, telemedicine, and telecare have been proved to be the technologies of the electronic age in the health domain. The first telemedicine was introduced in 1959 [39], which was the first research to make the efficient use of available resources using store-forward method which is one method of telemedicine/telehealth delivery. In this work the researchers broadly define telemedicine as a means to provide medical information and services through telecommunications technologies. Although this definition includes medical uses of telephone, distance education, telemedicine is increasingly being used as shorthand for remote electronic clinical consultation. Since it is the first telemedicine system it is somewhat expensive as well as the proposed telemedicine system can be characterized by type of information sent (such as radiographs or clinical findings) and by means used to transmit it.

Telemedicine for Diabetic Care

The other effort was by Gomez *et al.* [38] who developed for the help and care of diabetic patients. This system tries to show the potential benefits made available by telemedicine technology in diabetes care, and complements the daily care of diabetic patients. In addition, the other functions of the system include telemonitoring of patient's blood glucose levels and self-management actions, and remote care from doctors to diabetic patients. This DIABTel telemedicine system aims: to improve communication of the patient with the hospital-based diabetologist in between the patient's visits to the clinic, to allow doctors to assess the patient's condition on frequent basis every week, to help patients with management in the daily care of diabetes, and to provide patients with a service of supervised autonomy to increase patient's independence without decreasing the necessary continual support and supervision from the doctor. In general, the telemedicine system provides both doctors and patients with an integral service to manage and improve several aspects of daily diabetes care. Although the DIABTel telemedicine system supports only two basic functions; such as telemonitoring which support the control of glucose levels, diet, insulin dosage, and physical activity and telecare which supplies a two-way communication between patients and doctors, and yet does not address the problems related to patients and professional health education for more effectiveness.

Smart Phones for Older Chinese Diabetes

Microsoft Research and a group of researchers from several Universities in Chinese medical centers were developed a smart phone based self-management and support system for elderly diabetics in China [47]. The system uses smart phones to send elderly diabetics recommendations and guidelines related to physical activity, glucose and blood pressure

monitoring, weight measurement, and diet. Patients will be trained to enter and send data on glucose levels, and doctors will be able to track patient data and graphically display data for patients. The system allows data in the form of text. But it doesn't allow entering image and audio.

Telemedicine Network Model for Health Applications

The Institute of Tropical Medicine in Antwerp, Belgium, designed a low cost telemedicine project that was planned to facilitate the introduction of antiretroviral therapy (ART) for patients affected by Human Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) in developing countries, providing training, distance support and education to healthcare providers working in those settings [40]. The goal of this research work is to bind medicine with technology and to produce a robust system that delivers an acceptable service within appropriate price. This Telemedicine Network Model is presented for the developing countries specially Pakistan, which would improve the quality of medical facilities in the rural areas that contains an approximately 75% of the population with 22% of doctors working in those areas of Pakistan using the proposed Telemedicine Network Model. However, the proposed network model is limited to the cost effective use of medical resources to the people living in remote rural areas rather than country wide or it does not address the urban areas.

Mobile Health Advisory system

The other recent work, a mobile health advisor system for sexually transmitted infection, aimed to provide advice and treatments based on the selected symptoms of the patient is developed by Zukriya Abdella [18]. In addition, it helps patients on identifying the type of the disease based on

their symptoms and informs them to go to some specialized hospitals. However, the system is only focused on identifying the type of disease and informs the patients to the location of specialist hospital rather than educate people on how to prevent and manage diseases as well as guiding the patient and health professionals by providing basic health information service like how to prevent and control diseases either STIs or others to the public at large. Because the problem of some STI diseases (e.g., HIV/AIDS) which can be mentioned as chronic disease is related to disease prevention and control rather than cure.

Comprehensive Network Architecture for a Nation-Wide Telemedicine Network

A comprehensive network architecture for a nation-wide telemedicine network which connects all regional hospitals and health centers with the urban public/governmental hospitals is designed by Fikreyohannes Lemma [3]. In this work, the researcher tried to propose a web based telemedicine system that aims to provide the basic health services for medical tele-consultation. In its goal, the designed nation-wide network architecture as well as a web based system tries to provide a means to solve the problems on either doctor-to-doctor communication or any combinations of interactions between healthcare providers and tries to provide basic services for medical tele-consultation. However, the system does not consider the patients rather than health provider (health professionals, hospitals and health centers), i.e., there is no any means that the patients can access the system even if for tele-consultation.

PDA-based Client System

Medical Data Access with a PDA-based Client System developed by Dejene Hunde [4] allows medical specialists to access medical data from anywhere at any time. The designed client

system tries to solve the problems on accessing medical data remotely and it tries to improve the way of giving better treatment and guidance to patients. But the system is accessible only for medical specialists and it is limited to medical information. And also the researchers use MS-Access database to store and manage data. But MS Access database is more suitable for desktop use with a small number of users accessing it simultaneously even if it is chosen for the reason of compatibility/sharing. Also MS Access is limited to security in terms of username and/or password on the database. To solve these problems there may be the necessity of using MySQL which works on almost all platforms. In addition, it is more secured and can be configured with SSL support [48]. Also in the case of real commercial heavy duty database, MS Access is typically a local use. Therefore, it is no good for remote access as well as it is somewhat difficult for multiple user purposes.

Wireless Body Area Network for Computer Assisted Physical Rehabliation

In another study, the use of a wireless PAN protocol called ZigBee in a system that monitors patients' physiological signs remotely is proposed by *Emil et al.* [25]. The system is intended for use in computer assisted physical rehabilitation applications and ambulatory monitoring. It tries to provide a better and less expensive alternative for rehabilitation healthcare and may provide benefit to patients, physicians, and society through continuous monitoring in the ambulatory setting, early detection of abnormal conditions, and potential knowledge discovery through data mining of all gathered information. However, the system is limited to patient monitoring only on physical rehabilitation that may not assist the treatment of patients in their day to day care.

WLAN in Prehospital Environment

A wireless LAN prototype in a pre-hospital environment is developed by *Dongquan at al.* [42]. It provides the possibility for capturing clinical data in a prehospital setting using various devices such as PDAs, laptops, digital electrocardiogram machines, and even cellular phones, and transmitting the captured data to a physician or hospital. It means that the system allowed paramedic personnel to send patients' data (e.g., demographics and ECG) using PDAs and laptops from the patients' homes to ambulances parked outside. Data was then re-transmitted to the emergency rooms prior to patients' arrival to the hospitals. This allowed emergency room personnel to have timely access to patients' data in pre-hospital settings, resulting in better quality of care. In general, the system helps both paramedics and other healthcare professionals in their daily acquisition of information in a localized area such as within a patient's home, an office, or a small clinic. The system has less portability means that it is developed mainly based on windows operating system and Cisco wireless products. Therefore, the establishment and compatibility with other users require further evaluation.

Wireless Health Outcomes Monitoring System

The Wireless Health Outcomes Monitoring System (WHOMS), developed in [43], allows physicians to assess cancer patients' conditions in a remote setting. Questionnaires related to symptoms and quality of life is sent to patients periodically through their provided mobile phones. Patients respond to the questionnaires through mobile phones. Physicians can then access the results from any web browser. This enables physicians to continuously monitor patients' conditions without patient visits. When we talk about telemedicine or telehealth, there are two ways of transmitting the services such as real-time and store-forward and each of them

have their own advantages. For instance, real-time interaction and audio capabilities related to image acquisition, transmission, and display are more advantageous in some cases like teleradiology and telepathology. However, the existing WHOMS is limited to store-and-forward interaction method only as well as it does not allow patients to send image and audio.

Merging Telemedicine with Knowledge for the Management of Diabetes Mellitus

In addition to the aforementioned related works, there are other efforts which attempt to assist healthcare support based on Internet including M2DM [44] project which aims to merging of telemedicine with knowledge management in order to develop 24-hour telehealth support via multi-access services for the management of diabetes mellitus. However, the main focus of this M2DM system is limited to the essence of information exchange at a distance as well as on providing smart data analysis and knowledge management functions.

MyHeart

MyHeart [45] is a research project which runs for 72 months and funded by the European Commission's 6th Framework. The focus of MyHeart project is on preventing cardiovascular diseases by applying m-health applications. This work particularly focuses on the telemonitoring scenario, where sensors integrated in clothing are used to monitor heart activity and physical activity of the patient. Moreover, this project emphasizes the importance of specialized sensor and vice hardware to allow unobtrusive measurements. The MyHeart mission is to empower citizens to fight cardio-vascular diseases (CVD) by preventive lifestyle and early diagnosis as well as it is suitable for supporting citizens to fight major CVD risk factors and help to avoid heart attack, other acute events by personalized guidelines and giving feedback.

TRACnet

TRACnet [46] is a system designed to collect, store, retrieve, and disseminate critical program, drug, and patient information related to HIV/AIDS care and treatment using mobile phone. It has a central repository of HIV/AIDS information and delivers real-time information for decision making. The system has transformed a largely paper based one-way information flow that took several weeks into a bidirectional data exchange completed in seconds. It allows decision-makers and supervisors to quickly analyze and respond to program information. However, TRACnet is a proprietary application only supporting text data format (SMS), and does not allow the patients to interact with the system as well as there is no any chance for live interaction between patients and health professionals and professional to professional.

Mobile Telemedicine System for Home Care and Patient Monitoring

A Mobile Telemedicine System for Home Care and Patient Monitoring [49], aimed on patient monitoring by using the advantage of the serial port available in new mobile phones to implement a generic interface for patient monitors and users Internet connection of the mobile to transmit monitored data to the server for doctor evaluation. The system gets measured data from patient monitor through patient mobile. However, the system basically doesn't allow to entering data in the form of text, image, and audio as well as patients can't enter or send their status data through mobile phone.

Summary

Some limitations in using the existing health monitoring systems are: firstly, in some works there are lacks of inexpensive and user-friendly technologies in practice for the majority of elderly

people. Secondly, it needs to design an effective inference to provide effective information and real-time service, because the information including vital sign, location information, environmental information, etc., contain significant diverse aspects in both quality and quantity. Thirdly, the infrastructure requires system extendibility to introduce new network technology, diagnosis algorithm for analyzing condition of health, etc. in easy ways.

In general, the aforementioned related works show the possibilities of solving the problems in the health domain by applying various wireless technologies. However, most of these works focus on achieving remarkable improvement in curative aspect and less attention is given to health education on disease prevention and control, which is an important component of a health domain that can affect the overall outcome of a health domain. In addition to this, some of the existing related works focus on one specific area. For example, if one discovers a cure for cancer, but only half of the people have access to it, so in this way the researcher have only discovered half the cure for cancer. Discovering cure for one specific area by itself may not have any problems, but it is worthless if not applied appropriately to patients who need it. While in order to achieve holistic change in health domain, it is necessary to provide health information to the public and give awareness for remote people on disease prevention and health management. To do this, advances in telecommunications and information technologies can help to redistribute healthcare knowledge and expertise to where and when it is needed. These technologies can help to facilitate a new and more efficient way of providing care across the economic and geographic spectrum.

By considering the aforementioned gaps in the existing systems, we propose to design a telehealth support system which improves the quality of the current healthcare system by

incorporating health education for disease prevention and management in the existing health system. This helps the patients to have better awareness on how to prevent and control the spread out of communicable diseases. Also it allows patients to connect directly to their doctors or health professionals and enables them to access their medical history as well as their health progress from anywhere.

Chapter 4: System Analysis

System analysis is the part of the system development life cycle in which we determine how the current health system functions and assess what the user would like to see in the new system. During system development, there are expected level of capabilities like functionality of the system that are expected by the users of the system. To do this, during requirement elicitation we have gathered information and requirements of the system by using questionnaires [Annex B]. Additionally, different sites which can provide useful health related information have been visited.

This Chapter describes the analysis of the existing system to determine exactly how the existing system works as well as what problems exist and finally provide a solution to the problems. Also this Chapter provides the analysis of the interactions between the proposed system and its environment.

4.1 Existing System

The government is the main healthcare provider in Ethiopia. There are a number of hospitals, health centers, health posts, health stations, clinics, pharmacies, and drug shops [51]. However, the healthcare system of Ethiopia is among the least developed in Sub-Saharan Africa and at present it is not able to effectively handle the significant health problems facing the country [53]. Most of the health problems are associated with infectious diseases, communicable diseases, and nutritional deficiencies.

In addition to this, issues such as widespread poverty, low education levels, inadequate access to safe water, poor nutritional status, poor sanitation facilities, and poor access to health services have contributed to the high burden of the ill health situation in the country [52]. Indicators such as infant mortality (97 per 1000), under 5 morality (140.1 per 1000), and maternal mortality (871 per 100,000) speak more on the health and the general socioeconomic situation of the country [52]. Generally, life expectancy at birth is currently about 54 years and is expected to decline to 46 years if the present HIV infection rates are maintained. According to government statistics, 3.5% of the populations in the age group of 15-49 in 2005 are reported to have HIV/AIDS [53]. Malaria is the primary health problem in the country. In total, as much as 80% of the health related problems in the country are due to preventable communicable and nutritional diseases [53]. These are the major challenges the country is facing in its effort to reach the goal of universal coverage [51]. The government has chosen to strengthen primary healthcare as a strategic approach to solve the problems and to address a major gap in the country's healthcare system; lack of physical access to even basic healthcare facilities in rural areas. But, the healthcare delivery in primary healthcare facilities has been highly affected by the lack of skilled manpower and finance.

The country not only has limited number of health centers but also a big shortage of health professionals with one physician for 35,493 people and one nurse for 4206 people to cover the health services for the nation at large [50, 51]. A shortage of health professionals and health centers influences inadequate treatment for many people, especially in remote areas.

In the existing system to get health service, the patient has to go to the nearby health center and consult the health workers at the centers irrespective of whether the workers are specialized in

the area of his/her disease or not. Particularly, this problem is more challenge full for the patients with chronic diseases, which need continuous follow up as well as specialized professional's consultation on how to prevent and manage the disease. Additionally, the patients must go to the health center early in the morning and get registered to get a card for medical services. Since the number of health workers is limited in numbers, the user is expected to stay at the center and wait until his/her turn comes to see the health workers. This process may consume many times of the patient as well as the time of the health professionals. In addition to the time wastage, the patient might be asked for a costly service fee which he/she might not afford.

Due to the aforementioned and other problems, the existing health system is not a motivating system for patients to diagnose from time to time and to consult health professionals when needed. Not only for patients, health professionals also do not motivated to diagnose, treat, consult, etc. the patients using the existing system. Also a number of health centers are inadequate to provide health services within a short period of time with low cost. For both health professionals and patients in underserved areas with the lack of access to specialized medical centers, the only preferable way is to use new technologies to deliver as well as to access health services for all populations living in both rural and urban areas as well. Hence, wireless technology is the powerful tool to use.

The vastly growing of wireless technology has given rise to many applications which aimed to reach the wide population at large. Therefore, in consideration of the problems in the current system and the improvement of this highly developing wireless technology including PDAs, laptops, mobile phones, and Internet services, we have proposed to design Wireless Telehealth Support System which aims to solve the problems.

4.2 The Proposed System

4.2.1 Overview of the System

The proposed Wireless Telehealth Support System enhances the existing healthcare system by introducing various telehealth applications including remote health education on disease prevention and disease control/management (what to do and how to act during the increase of disease) as well as the system enhances the provision of health information service to the public at large. Also, the system recommends the patients to get more sophisticated treatment or consultation from specialized professionals as well as recommend any health professionals to get support from other specialists by informing where the specialized person is working or located and by allowing mailing or teleconferencing with the specialized person. This will help the users to save their time as well as make them to get the services easily being at the home or anywhere with low or no cost and high privacy. In addition to this, the system is user friendly by providing the users with some easily selectable features to select as they need and send it to the specialist or to any health professionals to get any support in different manner easily by using the proposed system.

4.2.2 Functional Requirements

From the requirement elicitation, we have gathered the following requirements. The system shall allow the health professionals including health extension workers, clinicians, nurses, specialists, medical doctors, etc. to:-

- send request for support on cases that they want a specialist's or other professional's support/advice.

- update or delete the previous request.
- receive the recommendations/advice made by a specialist for the request.
- give/get support to/from other specialists and discuss concerning a certain case if the case is somewhat difficult as well as if the available data cannot lead to definitive diagnosis in real-time interaction using teleconferencing or in store and forward telehealth system.
- exchange the patient's medical data securely for more clarifications.

The system shall allow:-

- the users to register themselves with the telehealth system through means of Internet facility either at home or at anywhere anytime with their mobile/wireless devices.
- Any registered user to get the privilege of accessing the telehealth system for any service like health education on disease prevention and management, consultation, accessing any clarification related to different diseases, etc.
- A registered user to maintain any requests using their devices.
- Patients based on their request to get response that suggests suitable tests which have to be carried out by the patient through the Internet.
- Patients with the assistance of a health professional to undergo the prescribed test.

The system shall allow the Coordinator (may be MOH or Administrator) to:-

- Manage announcements of different information.
- Manage user accounts.
- Maintain detail information of health professionals.

4.2.3 Non Functional Requirements

The non-functional requirements also known as quality requirements specify the quality of system attributes such as reliability and response time.

Usability

The system shall be developed in a way to be easy to use. Taking into consideration of the effectiveness of the usage of the system both for health professionals and patients, the system shall be designed to have easy navigations and some easy look and feel buttons/links with supportive tooltip and is easy to use. For those who will face a problem by using the system, a user manual [Annex C] shall be prepared along with tutorials.

Performance

When the system is a wireless mobile system which is available at anywhere, it might be accessed by hundreds or even thousands of users in a concurrent way. So, performance is the most important thing in our system and it shall be designed with high performance. It should also handle multiple users' requests at the same time and be responsive to the users' requests concurrently as well as the system should perform the tasks within a limited amount of time.

Security

To prevent unauthorized access of the system, it shall ensure that only authorized users access the system so that one cannot access a page which is beyond his/her privilege.

Availability

The system is a wireless system and it shall be available at any place and anytime.

Error handling

Invalid input from the users shall be handled in an interactive manner and appropriate messages would be displayed to the users.

4.3 System Model

System model is used to correct and captures all functionalities as well as to eliminates the unnecessary requirements. Analysis model mainly contains three models [54]. The first model is functional model that can be described by use case diagram, the second model is object model which is described by class diagrams, and the third one is dynamic model that can be described in terms of sequence diagrams, state chart, and activity diagrams. Regarding to this fact, we aim to construct the model analysis based on formalized requirements of the system. In our work, the analysis model will be described in terms of functional model, object model, and dynamic model using use case diagram, class diagram, and sequence diagrams respectively.

4.3.1 Use case Modeling

Actors

Actors are entities which can be a person or organization [55] that can play role in one or more interaction with the system. The system interacts with actors through various wireless devices and web interface. In our proposed system the actors and their description are listed in Table 4.1.

Table 4.1: Actors List with Descriptions

Actors	Descriptions
Health Extension Worker	A person who is assigned at kebele (village) level to provide basic health service for the community especially in remote/rural areas. Most of time they conduct house to house visit, educate families, monitor the spread out of communicable, deficiency, and epidemic disease. Therefore, they use the system for maintaining request to get the specialist's recommendations, maintain disease information, to support the patients.
Clinicians	A health professional that is not specialized in a specific area, but trained in a medical disciple which may include health officer, nurses, non-specialist medical doctors, senior staffs, and the like. Most of time these professionals are assigned and give service at the health center. They use the system to get support or consultation from a specialist on cases s/he has difficulty dealing with. They also exchange requests/information with patients.
Specialist	A health professional that has specialized in a specific area that can provide support or consultation to other specialists or health professionals. Use the system to handle consultation/ support request either by health professionals or patients, to get information.
Patient	An authorized user of the system that can access the system through his/her mobile devices to get telehealth services at any time anywhere. S/he is also responsible for filling the forms that contain his/her relevant information which can be used to sending and receiving the requests.
Administrator	This is a person who is responsible for administering the whole system and

	capable of modifying and making changes to the system as well as manage the system users and responsible for adding, removing, and editing user information.

Use Case Diagram

The use case diagram that depicts the overall description of the telehealth support system is shown in Figure 4.1.

Use case Diagram

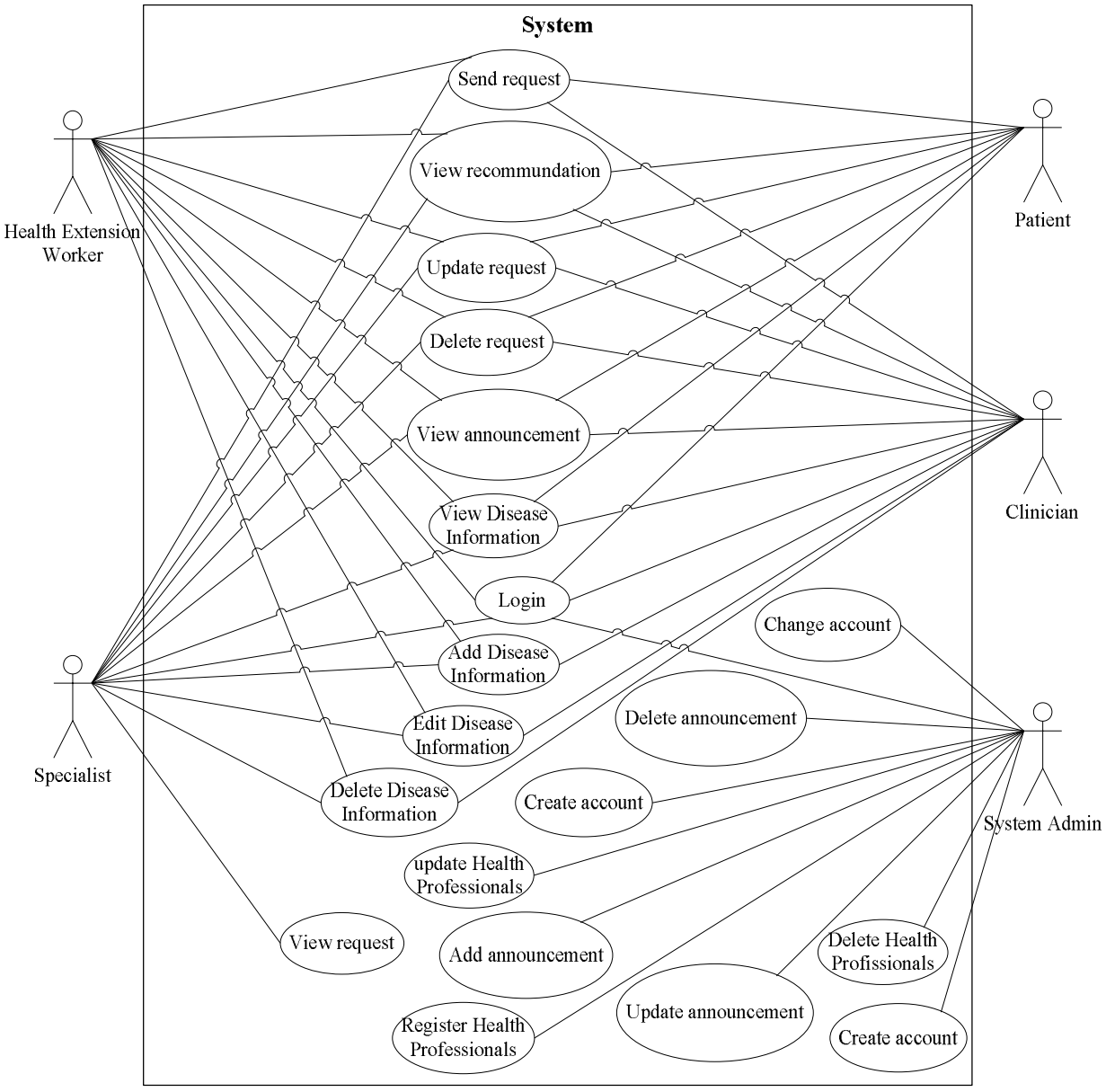


Figure 4.1: Use Case Diagram of Telehealth Support System

Use Case Description

1. Use case name:	**LogIn**
Actors:	Health Extension Worker, Administrator, Clinician, Specialist, and Patient.
Purpose:	It helps the aforementioned actor to login to his/her page.
Precondition:	The actors should have an account (username and password).
Flow of events:	1. Actor clicks on the Login link 2. System displays Login form that requires username and password. 3. Actor fills the required username and password, and clicks on the "proceed" button. 4. System verifies the eligibility of the actor and displays his/her page accordingly. [Alt. A] Alt 4: Invalid username and/or password.
Alternate Event flow A:	4.1 System displays error message; incorrect username and/or password and re-displays the Login form which have the option for forgot password 4.2 The actor repeats step3 with correct username and password or exit.
Post condition:	The aforementioned actors go to their respective page and perform their tasks as they need.

2. Use case name:	**Add announcement**
Actor:	Administrator
Purpose:	It allows the Administrator to add/post new announcements.
Precondition:	Administrator must Login to his/her respective page
Flow of events:	1. Administrator clicks on the Maintain_announcement link.

	2. System displays announcement maintaining form with operation add/post, update, delete, clear/rest, and exit. 3. Administrator completes the needed information and press the "Add/Post" button. 4. System verifies the invalid inputs and acknowledges as well as save the added announcement for the future use.[Alt A] Alt 4: Invalid input or empty fields.
Alternate Event flow A:	4.1 System displays an error message invalid input or database transaction error or fields cannot be empty. 4.2 Administrator repeats step 3 and correct invalid inputs and empty fields or exits
Post condition:	Administrator add/post new announcement as well.

3. Use case name:	**Update announcement**
Actor:	Administrator
Purpose:	It allows the Administrator to edit the existed announcements for the users.
Precondition:	Administrator must Login to his/her respective page
Flow of events:	1. Administrator clicks on the Maintain_announcement link. 2. System displays announcement maintaining page with operations add, update, search, delete, clear/rest, and exit. 3. Administrator inserts infoID on informationID field and click "search" button.

	4. System verifies for information and display the searched information [Alt A]. Alt 4: Invalid infoID. 5. Administrator edits the needed announcement and presses the "Update" button. 6. System verifies the invalid inputs and acknowledges as well as save the updated announcement for the future use.[Alt A] Alt 6: Invalid input or empty fields.
Alternate Event flow A:	4.1 System displays an error message invalid infoID or no announcement with this ID. 4.2 Administrator repeats step 3 and use valid/existed infoID or exits 6.1 System displays an error message invalid input or database transaction error or fields cannot be empty. 6.2 Administrator repeats step 3 and correct invalid inputs and empty fields or exits
Post condition:	Administrator update announcement as well.

4. Use case name:	**Delete announcement**
Actor:	Administrator
Purpose:	It allows the Administrator to delete the existed announcements.
Precondition:	Administrator must Login to his/her respective page
Flow of events:	1. Administrator clicks on the Maintain_announcement link.

	2. System displays announcement maintaining page with operations add, update, search, delete, clear/rest, and exit. 3. Administrator inserts infoID on informationID field and click "search" button. 4. System verifies for information and display the searched information [Alt A]. Alt 4: Invalid infoID. 5. Administrator presses the "Delete" button. 6. System acknowledges and delete announcement.
Alternate Event flow A:	4.1 System displays an error message invalid infoID or no announcement with this ID. 4.2 Administrator repeats step 3 and use valid/existed infoID or exits
Post condition:	Administrator update announcement as well.

5. Use case name:	**Register health professionals**
Actor:	Administrator.
Purpose:	Enables the Administrator to register new health professional with the details of necessary information that can be viewed by other users.
Precondition:	Administrator must Login to his/her respective page
Flow of events:	1. Administrator clicks on "Maintain professional profile" link/button. 2. System displays health professional maintaining page with various operation Register, update, delete, search, reset/clear, and exit.

	3. Administrator completes the needed professional's detail information and press "Register" button. 4. System check if there is empty fields and acknowledges as well as save the registration information of professionals to the database for the future use.[Alt A] Alt 4: Empty fields or invalid input
Alternate Event flows:	4.1. System displays an error message because of empty fields and invalid input. 4.2. Administrator repeats step 3 and check for invalid input and empty fields and correct them or click exit.
Post condition:	Administrator register the detail information of professionals as needed.

6. Use case name:	**Add disease information**
Actors:	Clinicians, Health Extension Worker, and Specialist
Purpose:	Actor enables to add different useful information about various diseases.
Precondition:	Actor must have account.
Flow of events:	1. Actor click on "Maintain disease information" button/link 2. System displays login form with fields that ask usertype, username, and password. 3. Actor selects usertype as well as insert username and password. 4. System displays disease information maintaining page with operations like add, update, delete, search, reset/clear, and exit.

	Alt 4: Invalid username and/or password 5. Actor fills the fields with relevant information and press "Add" button. 6. System check if there is empty fields or invalid inputs and acknowledges as well as save the detail information of disease to the database for the future use.[Alt A] Alt 4: Empty fields or invalid input.
Alternate Event flow A:	4.1. System displays an error message because of incorrect username and/or password. 4.2. Actor repeat step3 click exit. 6.1. System displays an error message because of empty fields and invalid input and stay in step 3. 6.2. Administrator check for invalid input and empty fields and repeats step 3 to correct the error or click exit.
Post condition:	Actors Add any disease information.

7. Use case name:	**View disease information**
Actors:	Clinicians, Patient, Health Extension Worker, and Specialist
Purpose:	Enables actors to view different useful information related to disease prevention, controlling methods symptoms, disease type, etc.
Precondition:	None
Flow of events:	1. Actor click on "view disease information" button/link 2. System displays view disease information page with simply look and

	selectable options for disease type, prevention method, controlling methods, symptoms, etc. 3. Actor selects and clicks any type of information that s/he wants to view. 4. System displays the required information from the system's database [Alt A].
Alternate Event flow A:	4.1 System displays an error message because of operation failure. 4.2 Actor repeats step 3 or exits.
Post condition:	Actor views any information as his/her need.

8. Use case name:	**View announcement**
Actors:	Clinicians, Patient, Health Extension Worker, and Specialist.
Purpose:	Actor enables to view if there is any new announcement.
Precondition:	None
Flow of events:	1. Actor clicks on "view announcement" button/link 2. System displays the required announcement from the system's database [Alt A].
Alternate Event flow A:	4.1 System displays an error message because of operation failure or an information message because of no new announcement 4.2 Actor repeats step 3 or exits.
Post condition:	Actor views any announcement if it is available.

9. Use case name:	**Create account**
Actors:	Administrator
Purpose:	It enables Administrator to create users' account.
Precondition:	Administrator must login to his/her respective page.
Flow of events:	1. Administrator click on "Maintain user account" button/link. 2. The system displays user account maintaining page that contains list of possible options (create, edit, delete, search, clear/reset, and exit.) 3. Administrator clicks on "Create_Account" link 4. The system displays user account creating form that contains fields for username, password, confirm password, and usertype (selectable option) with "Create" button. 5. Administrator fills the fields with relevant information and press "Create" button. 6. System check if there is empty fields or invalid inputs and acknowledges as well as save the account information to the database for the future use.[Alt A] Alt 4: Empty fields or invalid input
Alternate Event flow A:	4.1 System displays an error message because of empty fields or invalid input and stay in step 3. 4.2. Administrator check for invalid input or empty fields and repeats step 3 to correct the error or click exit.
Post condition:	Administrator creates user account successfully.

10. Use case name:	**View Request**
Actor:	Specialist
Purpose:	It allows specialist to view/read the coming request which is sent by other specialists and/or patients.
Precondition:	Specialist must Login to his/her respected page.
Flow of events:	1. The specialist clicks on "View Request" button to view the received request. 2. The system displays the received request [Alt. A]. 3. The specialist select "Save" or "Discard" button after reading the request. 4. The system saves the request for future use if the specialist clicks "Save" as well as delete from database if specialist clicks "Discard".
Alternate Event flow A:	2.1 System displays an error message because of problems on database transaction or operation failure. 2.2 Specialist repeats step 1 or exit.
Post condition:	Specialist views the received request if it is available.

11. Use case name:	**Send Request**
Actors:	Clinicians, Health Extension Worker, Specialist, and Patient
Purpose:	It enables Actor to send request.

Precondition:	None
Flow of events:	1. Actor clicks on “Maintain request” button 2. The system displays request maintaining page that contains operations (register, update, delete, clear/reset, and exit.) with a number of fields. 3. Actor completes the fields with relevant information and press “Register” button. 4. System check for empty fields or invalid inputs and acknowledges; then displays request sending form with simple look fill or selectable options.[Alt A] Alt 4: Invalid inputs or empty fields 5. Actor completes and press “Send” button. 6. The system verifies and acknowledges as well as saves the details of request for future use. [Alt. A]
Alternate Event flow A:	4.1 System displays an error message because of empty fields or invalid input and stay in step 3. 4.2. Administrator check for invalid input or empty fields and repeats step 3 to correct the error or click exit. 6.1 System displays an error message because of problems on database transaction or operation failure. 6.2 Actor repeats step 5 or exits.
Post condition:	Actor registered and send request.

4.3.2 Class Diagram

Class diagram is a mechanism of depicting the different classes and their activities together with the relationship that exists among classes and connect each other to their contents. It describes the system in terms of objects, attributes, and operations with their association. Moreover, class diagram shows the overall structure of the system. The class diagram of Telehealth Support System (TSS) is shown in Figure 4.2.

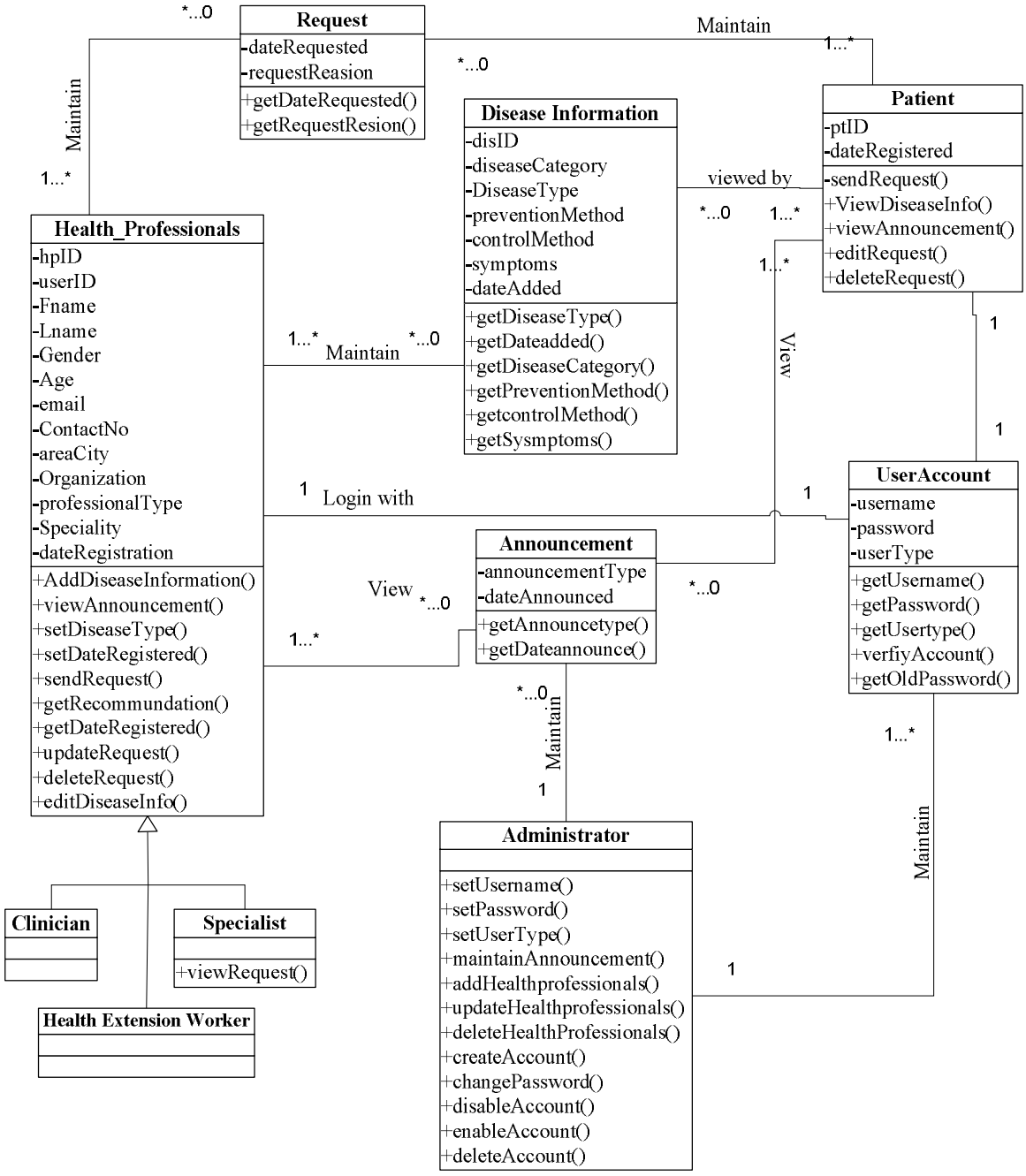


Figure 4.2: Class diagram of Telehealth Support System

4.3.3 Sequence Diagram

Sequence diagrams are an easy way of expressing the behavior of the system by showing the interaction between object entities which participate to accomplish the task described in the use case [56, 57]. Communication between objects is by message passing between objects. Objects are represented as columns with the vertical broken line to represent the life time of the object. The sequence diagrams of use cases are shown in Annex A.

Chapter 5: System Design

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements [58]. During the design phase, we must transform the analysis model into a system design model. The objective of design is to model the system with high quality. This Chapter will discuss the details that need to be defined in order to run the requirements stated in the previous section to a final implementation, i.e., there is a shift from the application domain to actual implementation.

The task of system design includes the definition of design goals of the system, decomposition of the system into subsystems (categories) which refers to the process of breaking down the system into manageable pieces to understand the complexity of the system, hardware/software mapping showing the deployments of the components, and persistent data model that describes the database structure.

5.1 Design Goals

Design goals describe many of the quality aspects of the system that should be satisfied for the final product. It can be identified from the non-functional requirements of the system. System qualities are often expressed as non-functional requirements, also called quality attributes. These are requirements such as reliability, usability, maintainability, cost, development time, and the others which are crucial for system quality. Some of these design goals of the telehealth support system are discussed as follows.

Performance

Most of the time performance may be defined in terms of response time, memory, and concurrent user support. In the case of hardware or network failure, the users should be informed immediately. To increase the performance of the system, we shall develop the system to the best possible algorithms which take fewer amounts of time and memory to process a task. The system should transmit as minimal data as possible.

Maintainability

If there is anything that is necessary to add on the system, the system should be easily extensible and modifiable to incorporate additional functionalities and changes without causing any problem to other systems functionality. Since the system is designed with object oriented approach and with different modules, any developer can easily maintain and modify without affecting the other functionalities.

Security

Privacy issue of the users is very sensitive. Specifically in telehealth since the information transmitted over the network contains personal medical information both the mobile client and the server should protect the transmitted content during communication. Therefore, the database which stores passwords should be encrypted with MD-5 algorithm which is difficult to decrypt. This system user's authentication with username and password play pivotal role in ensuring security. Also the J2ME platform supports HTTPs for MIDP. As a result, the system uses secure HTTP to send and receive information like patient medical history, requests and others.

User Interface

Since the system is expected to be user friendly, it should have a simple user interface that can be easy and used by users without difficulties since the users may have less experience in using computing technologies. The interfaces encompass different buttons and links with tool tip which are very simple to use and make users feel comfortable during the use of the system. Also the user interface on the wireless devices like mobile phone should have to be compatible and simple as it will be displayed on small screens.

Error handling

The system shall be developed not to accept invalid input in any way and both client side and server side form validation will be made to ensure this.

Availability

Since the system is a wireless system, it should be available and provide its service at anytime and anywhere as the users need to access it. The probability of unavailability of the system to users is in times when there is system maintenance and these tasks will be conducted when users are not supposed to be accessing the system (for example at mid night). The system will be available to the users through a wireless Internet connection using various types of wireless network. Moreover, the system prototype is developed using Connected Limited Device Configuration (CLDC) of J2ME platform. The "Connected" simply refers to a network connection that tends to be intermittent and probably not very fast. Therefore, if there is intermittent connection to the Internet or the failure of Internet connection, the system tries to overcome the problem or it tries to store the request locally and recovers from a temporary

occurrence of connection failure and retries sending the data automatically without requiring the user to input the data again when connection is re-established automatically.

Portability

The health professionals and system administrator can access the system through web browsers and the system should have to support requests coming from different platforms via standard web browsers. The patients can access the system via any wireless device which supports Java programming and the system should have to run on any wireless device like mobile phone which is capable of running Java programming.

5.2 System Architecture

The system architecture shows the overall organization and communication between the users and the system. The main components of the system architecture include mobile client, web client, and system server. Figure 5.1 shows the general architecture of the system.

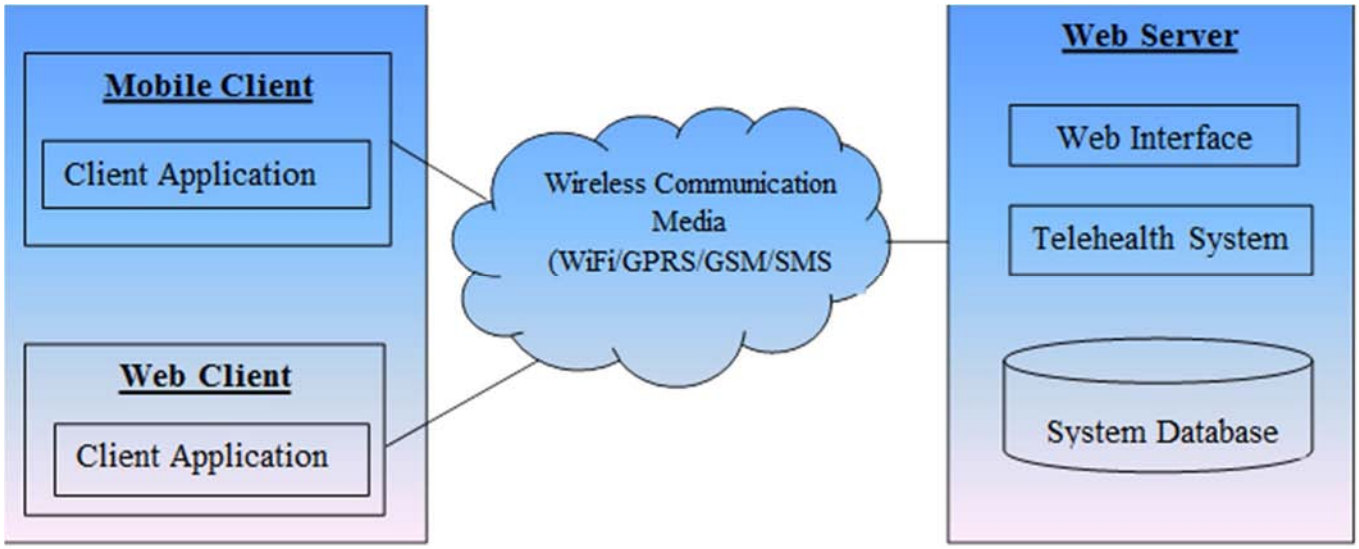


Figure 5.1: The General Architecture of the Proposed System

Mobile Client

The mobile client component is the client side application of the system which runs on small wireless hand-held devices like mobile phones. This component helps the users of the system to get different telehealth services such as enabling the patients to communicate with their respective health professionals and vice versa, as well as health professionals with other health professionals through their wireless devices. It contains different forms, procedures and settings which are filled by patients based on their needs and by health professionals regarding their desired support. Mobile client component communicates with web server side of the system through the use of different wireless communication technologies including mobile communication networks ranging from 2G (GSM) to 3G (W-CDMA, CDMA2000, TD-CDMA), WLAN GPRS, WiFi, and other networks.

Web Client

This is the other client side application of the system which helps the users of the system who use laptop or desktop computers to get telehealth services. Through this component, the system administrator can manage and access the system, health professionals can support patients and they also can get/give supports from/to the other professionals.

Web Server

The server side application of the system including web interface and database application resides on the web server. This also contains the telehealth application which is the heart of the system. It is responsible for any kind of communication among patients, health professionals and system administrator through its web interface as well as it contains patient medical history,

system user information, various profile information of the health professionals, general disease information, and request information through its database module.

5.3 Subsystem Decomposition

In order to make the system design and development easier, the system is decomposed into manageable smaller components/parts called subsystems which contain the group of the classes with similar functionality. This also helps to understand the problem better. During system decomposition, achieving strong coherence within the subsystem and loose/low coupling between subsystems were taken into consideration. The major subsystems of the system are shown in Figure 5.2.

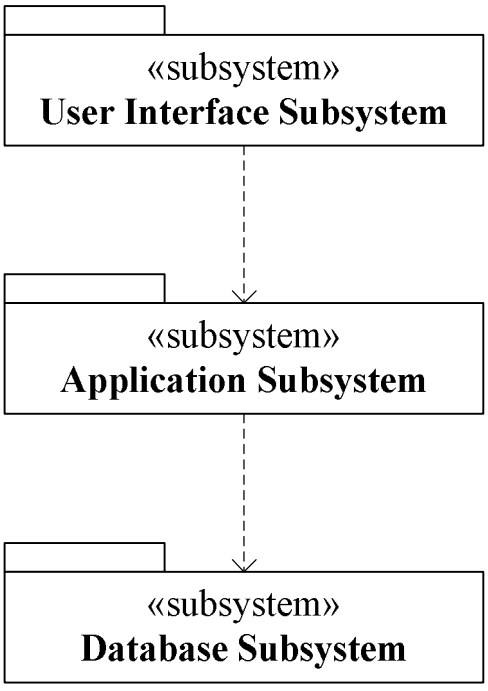


Figure 5.2: Subsystem Decomposition of Telehealth Support System

The detail description of each subsystem is discussed as follows:-

User Interface Subsystem: is mainly responsible to facilitate the interaction of the user with the system. The services of this subsystem are accepting user inputs, shaping them in such way that they can be used by the system, and displaying results that are processed by the system. This subsystem has the following other smaller subsystems:

- **Mobile/Web UI subsystem:** the main concern of this subsystem is providing an interface to register user's information that used latter to maintain (send, edit, and delete) request. This interface also provides the interface to view request and receive recommendations. For Administrator it provides an interface to maintain (register, edit, and delete) health professionals.
- **Security UI subsystem:** this subsystem provides an interface to insert username and password in the case of login to the system or in the time to update or delete the requests in order to authenticate the system users. It also provides an interface for the administrator to maintain (create, update, delete, and disable) account.
- **Data management UI subsystem:** this subsystem concern on providing an interface for the health professionals which enables them to maintain (add/record, update, and delete) disease information regarding with disease category, disease type, prevention method, controlling method, and symptoms of the diseases. For other users this subsystem provides an interface to view more additional information about any diseases.

Application Subsystem: this subsystem is mainly responsible for managing any operation and communication in relation to health education, diagnosis, patient and/or health professionals'

request, and user control. This subsystem has other small subsystems: user control, manage request, and manage forms.

- **User Control subsystem:** this subsystem concern on controlling the users of the system (such as health professionals, Patients, and system administrator).
- **Manage Request subsystem:** this subsystem enables the health professionals and/or patients to send request, update and delete their previous request. Additionally, this subsystem accepts various data from database and sends it to mobile/web UI.

Database Subsystem: this subsystem provides facilities for persistent data storage, executing the SQL statements, storage and retrieval of files, and ensuring data consistency.

5.4 Hardware/Software Mapping

The hardware/software mapping model of the system describes the relation between the hardware and software components and nodes as well as the communication technology that can be used for the system. The system client application is deployed on mobile devices and personal computer, the server-side web application is deployed on web server, and the database application is deployed on MySQL database server. Figure 5.3 shows the hardware/software mapping (deployment) of the telehealth support system.

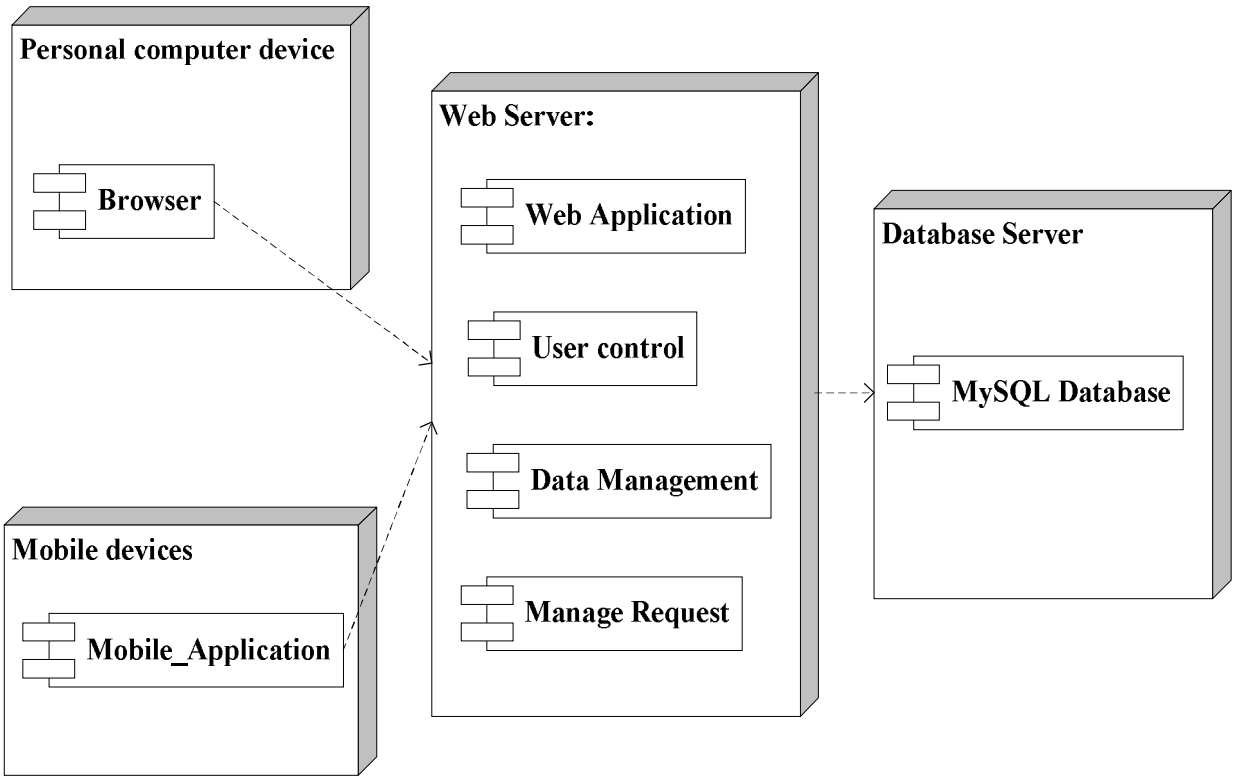


Figure 5.3: Deployment diagram of Telehealth Support System

5.5 Persistent Data Management

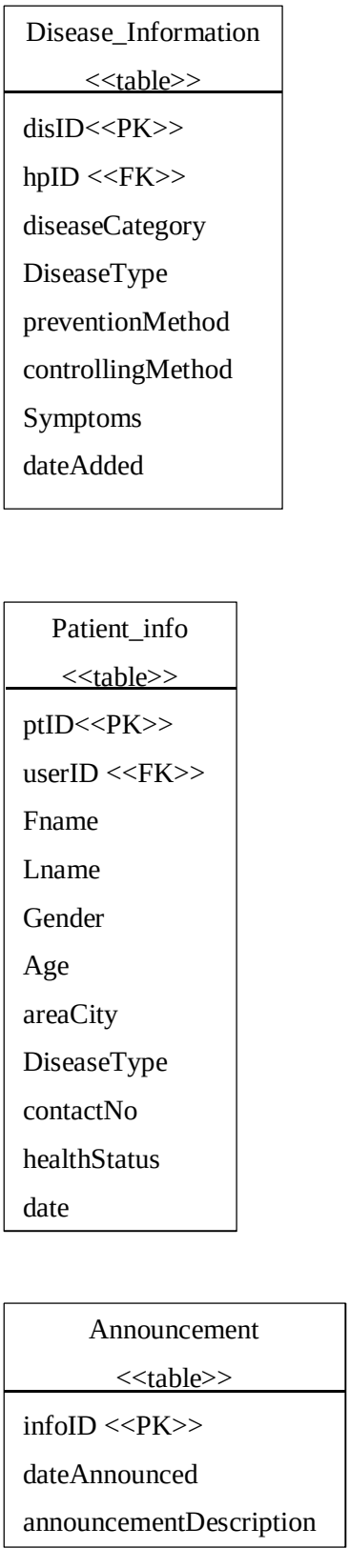
Relational databases are often used as a mechanism to store the applications objects persistently. This section describes about the data that are stored persistently. In order to store, retrieve, and analyze data for future use persistent data management is necessary. Regarding to this, database system is designed to store different kinds of data in the central system. In MIDP, persistent storage is centered on record stores. A record store refers to an application programming interface that is used to store and manipulate data in small computing mobile devices using a J2ME application that contains pieces of data called records and is represented by instances of

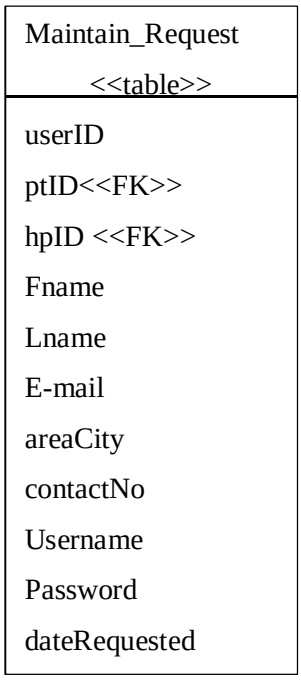
javax.microedition.rms.RecordStore. We used MySQL database server and we have database called “telehealthsupportsys” with different tables. Figure5.4-5.10 shows mapping of objects to relational database.

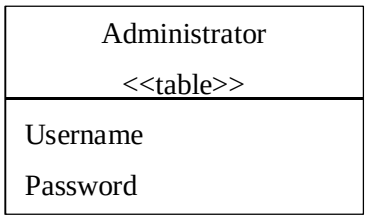
5.5.1 Mapping Objects to Tables

Health_professionals <<table>>
hpID <<PK>>
userID <<FK>>
Fname
Lname
Gender
Age
E-mail
areaCity
Organization
professionalType
speciality
contactNo
registrationDate

User_Account <<table>>
userType
Username
Password


Disease_Information
<<table>>
disID<<PK>>
hpID <<FK>>
diseaseCategory
DiseaseType
preventionMethod
controllingMethod
Symptoms
dateAdded
Patient_info
<<table>>
ptID<<PK>>
userID <<FK>>
Fname
Lname
Gender
Age
areaCity
DiseaseType
contactNo
healthStatus
date
Announcement
<<table>>
infoID <<PK>>
dateAnnounced
announcementDescription


Maintain_Request
<<table>>
userID
ptID<<FK>>
hpID <<FK>>
Fname
Lname
E-mail
areaCity
contactNo
Username
Password
dateRequested


Administrator
<<table>>
Username
Password

Chapter 6: Implementation

6.1 Development Environment

To develop the proposed system the following tools and technologies were utilized.

Java 2 Enterprise Edition (J2EE): the Java programming language is used to develop both server side and the personal computer client side application of the system.

Java Server Pages (JSP): Java Server Page is used to design the web interface for the server side application of the system.

Java 2 Micro Edition (J2ME): the J2ME is a CDLC/MIDP platform which is used to develop and demonstrate MIDlet applications running on mobile clients. In order to run MIDlet applications on the target small computing device, the .JAR and .JAD files are installed in mobile devices.

Wireless Toolkit 2.5.2: this is a plugin that is used to facilitate the development of the mobile client side application of the system. The J2ME Wireless Toolkit is a comprehensive set of GUI tools that automates some of the tedious details of building and packaging MIDlets and providing a simple path from source code to running MIDlets. J2ME Wireless Toolkit also can be used as standalone or incorporated into many popular Integrated Development Environments (IDEs) as well as it provides the byte code pre-verification tool, implementation of API class libraries, and a device emulator [59].

NetBeans 7.3: the NetBeans 7.3 IDE is used as integrated development environment for both the client side and server side applications of the system.

MySQL: is used for developing a database that stores information about system users, maintained requests, healthcare providers, and others. MySQL server is selected because it is free and open database management system and it is capable of working with server-side scripting languages as well as it is capable of handling huge amount of data.

Microsoft Visio: is used for designing different UML diagrams that are used during different developing phases of the system.

6.2 The Prototype

The prototype of the system is composed of a mobile client application running on small wireless computing devices like mobile phones, a web client application running on personal computers and a server side application capable of handling the user requests.

Mobile Client Application Interface

The mobile client application interface is an interface for the mobile client application that can run on mobile devices. When the application is started on mobile devices, it displays the login form that requires users to enter their username and password and verify the user's authentication. The login form of mobile application is shown in Figure 6.1.

Figure 6.1: Login Form for Mobile Client Application of Telehealth Support System

On a successful login to the system, the system displays the main menu of the system with different options. From the listed application if the user selects the "Maintain Request" button, the system displays the request maintaining page as shown in Figure 6.2, but in this page there may be the need of registration before sending, updating, and deleting the request which are found under "Menu". The registration form, shown in Figure 6.2 contains various information about the requester which are used for future process.

Figure 6.2: Registration Form for Mobile Client Application of Telehealth Support System

After the user is registered for the request, the user can send the request by selecting from the given options as well as s/he can send, update, and delete the request. Register for request sending has its own advantage, for example, if the user wants to update and resend the request, s/he will not be asked for re-registration as well as the users can simply search and update or delete their previous request using only

the username and password. Figure 6.3 shows the request sending form with different list of options, list of symptoms with check boxes, list of the methods of communication, option for telehealth education.

Figure 6.3: Maintain Request for Mobile Client Application of Telehealth Support System

The result is sent to the mobile client after sending the symptoms and receiving sent request confirmation message. Figure 6.4 shows the result of the request based on some selection of the user. If the user needs details about various disease s/he can click on “Disease information” link

to get more understanding on how to prevent, control the disease, symptoms of the disease and other information from the system.

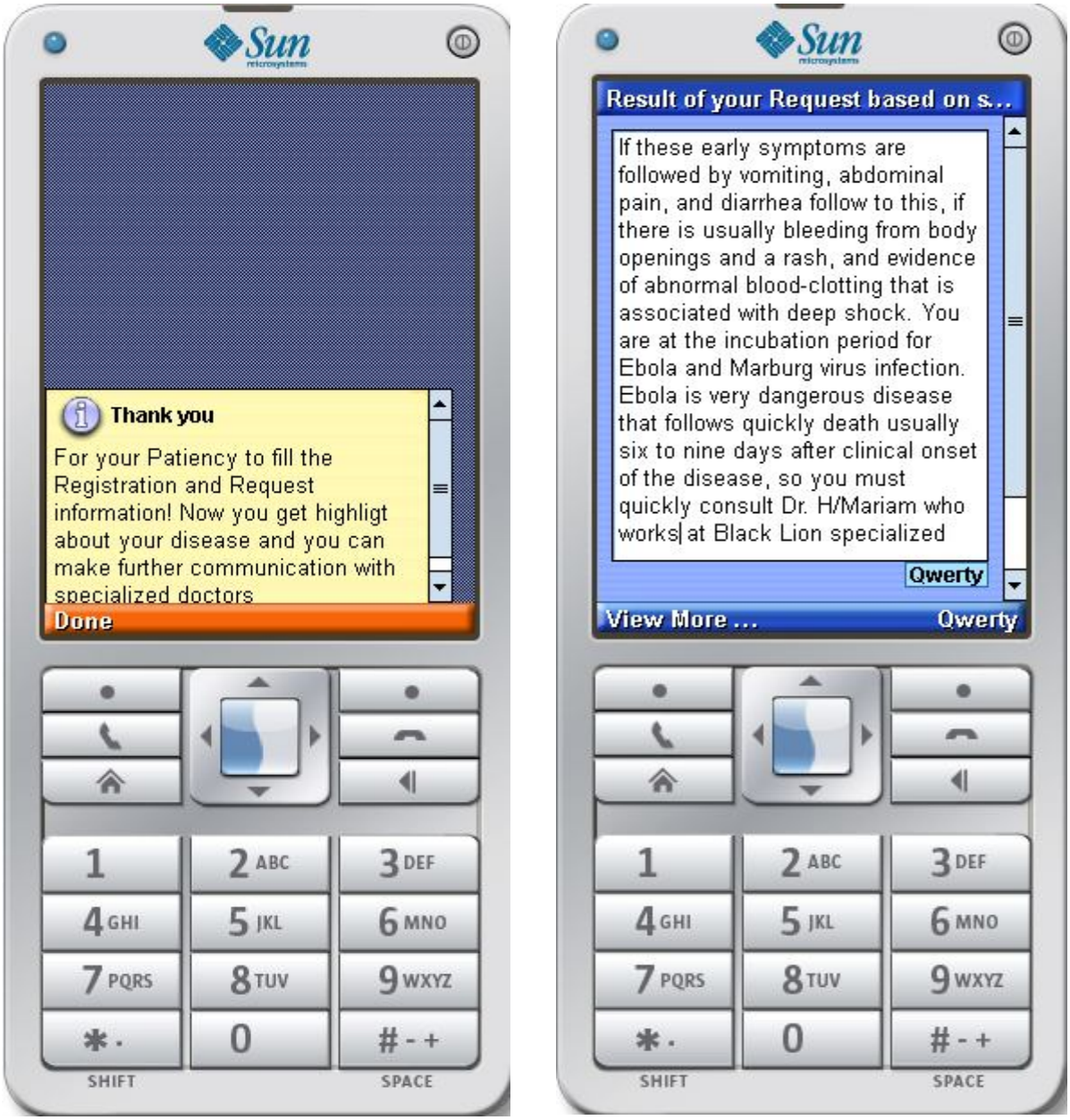


Figure 6.4: Result of the Request for Mobile Client Application

Web Client Application Interface

The web client application interface is an interface for the web client application that can run on personal computers (such as laptop or desktop). When the application is started on these devices and if the user clicks on login button, it displays the login form that requires the users to enter their usernames and passwords and verify the user's authentication in order to login to the system. The login form of web client application is shown in Figure 6.5. Otherwise, if the user selects another operation like "Maintain_Request", the application takes the user to maintain page that allows him/her user to register for sending request and allow the user to update and delete the existing request as shown in Figure 6.9 and Figure 6.10 respectively.

Figure 6.5: Login Form for Web Client Application of Telehealth Support System

After the users have selected and filled in input fields of login form with correct login credentials, the system displays the respective pages based on the selected and filled login credentials. On successful login, the user is logged in as an Administer, application takes the user to Admin page which contains

different tasks that s/he performs as shown in Figure 6.6. Then from these options if the administer selects the “Maintain health Professionals Profile” link and s/he can register new health provider profile, update and delete the existing profiles of the health professionals by filling the necessary requirements as shown in Figure 6.7. This is further to inform the patients or other health professionals. On the other hand, if the patient or health a professional wants to look at and get consultation or support from specialists, s/he can simply view some information by clicking on view professionals profile button. Also, if the administer want to performs other operation may be maintain the user account, he/she perform the task by providing the necessary information that is required to maintain user account as shown in Figure 6.8.

Figure 6.6: Admin page of Web Client Application of Telehealth Support System

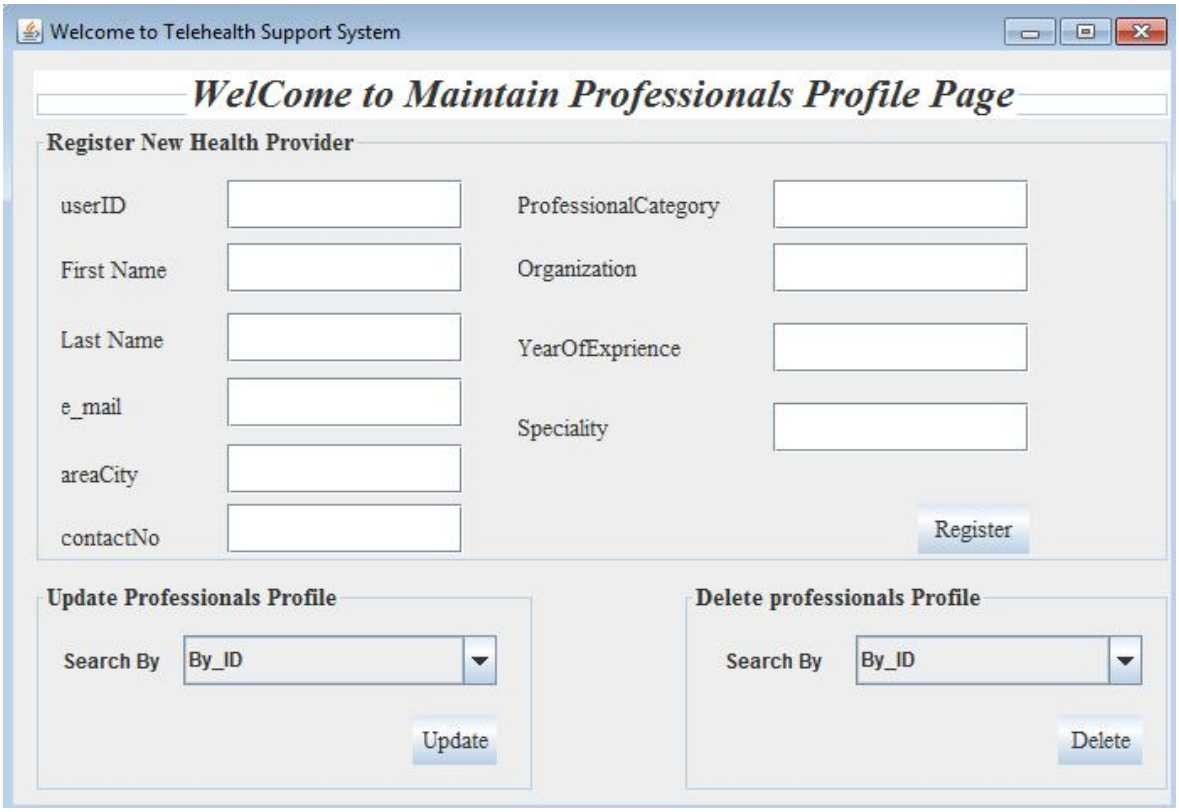


Figure 6.7: Maintain professionals profile page for Web Client Application

Figure 6.8: Maintain Account Page for Web Client Application of Telehealth Support System

Similar to mobile client application, if the user wants to maintain request using web client application first he/she clicks on “Maintain Request” button, then the system displays the maintaining request page as shown in 6.9. In this page, the user is also asked to make registration before sending, updating, and deleting the request. Figure 6.10 shows the registration form, for web client application which contains various filling and selectable options that are used to store information about the requester for further use.

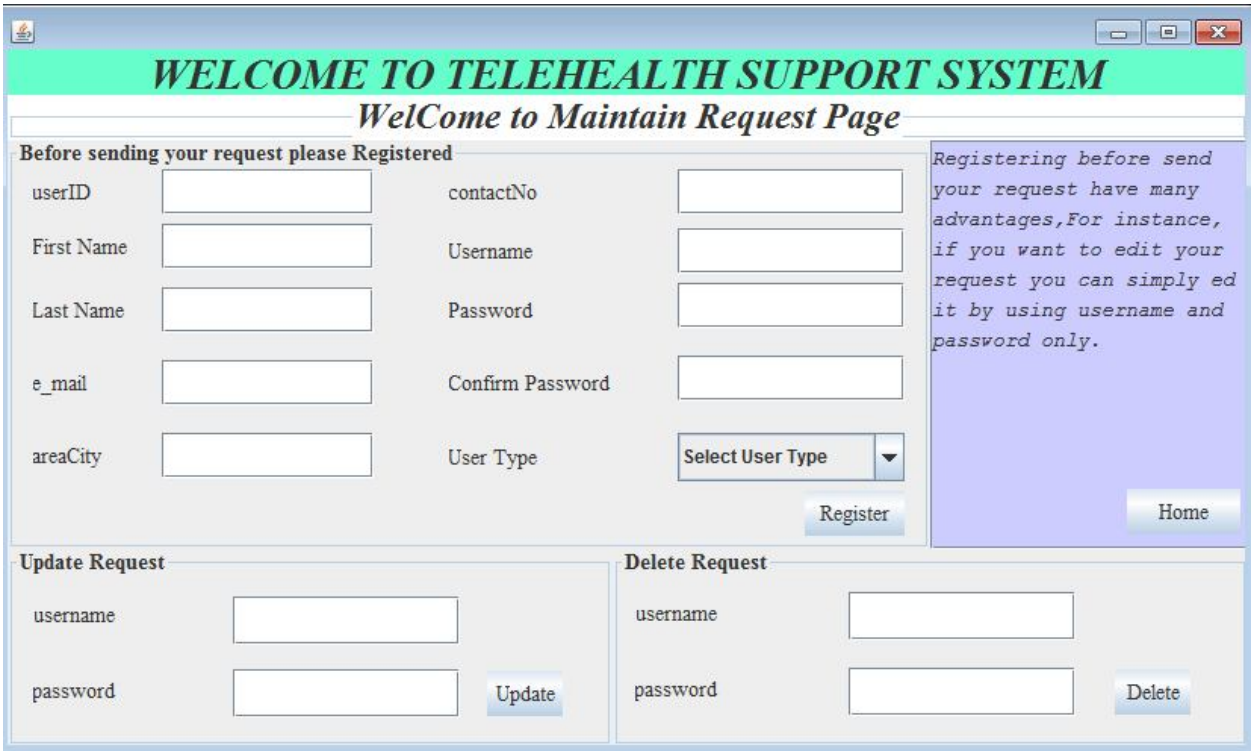


Figure 6.9: Maintain request page for Web Client Application of Telehealth Support System

Figure 6.10: Send Request page for Web Client Application of Telehealth Support System

After completion and sending the selected options as well as receiving the sent request confirmation message, the result is sent to the web client. Also, if the user needs details about the disease s/he can click on “Disease information” link and get more awareness on how to prevent and manage and/or control the disease and other information from the system as well as to distinguish the symptoms of the diseases.

Server Side Application

The server side application of the system contain database application resides on the web server. It is responsible for contains patient medical history, system user information, various profile information of the health professionals, general disease information, and request information.

Chapter 7: Conclusion and Future Works

7.1 Conclusion

In developing countries like Ethiopia, there is a high shortage of medical health professionals that affects the quality of healthcare of people. Due to this and lack of adequate guidance and treatments as well as lack of awareness on the prevention and control of various type of disease, a patient may suffer tremendously to the extent of losing life. Regarding to this reality, there should be a means to exploit the health professionals in the country in order to give the effective services. To alleviate these problems, using wireless technologies a telehealth support system which supports the existing system by incorporating health education and related services on disease prevention and controlling is proposed in this work.

Using the developed system, both health professionals and/or patients can access the health services while on the move or while they are away from their living or working site to give and/or get better treatment and guidance. This is very important and practical in the areas with very high shortage of medical professionals. We believe that this empowers the health professionals to have adequate health services access from anywhere and to give effective services to the patients. Therefore, this helps to effectively utilize the insufficient resources, infrastructure and health professionals in the country. Also, this improves the quality of patient care, awareness around the people, since it enables both health professionals and patients to have adequate access to the health services and information.

Due to the limitations of material resources and shortage of time, in the development phase of the prototype, MIDlets applications are executed using a Java 2 Micro Edition CLDC/MIDP

emulator that emulates a physical mobile device. A Java 2 Micro Edition CLDC/MIDP emulator is an important tool that ships with the standard J2ME Wireless toolkit and allows the demonstration of MIDlet based applications in web browser applet. The J2ME emulator is also a tool that enables us to run MIDlets on mobile devices such as mobile phones as well as on a laptop and desktop PC and simulate how the MIDlet will run on a physical device.

7.2 Future Works

As we mentioned in the previous section due to the limitations of material resources, in the development phase of the prototype, we use emulators to demonstrate the prototype in a physical mobile device. However, the develop telehealth support system allows health professionals and/or patients to access health related services from wherever they are.

Our system is particular applicable only for health education on disease prevention and control, health management, and health information services for communicable disease and diet-deficiency diseases. In the future works, we will extend this health education service with other telehealth applications to various types of health problems like medical prescription as well as for all type of disease.

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Annex A: Sequence Diagrams

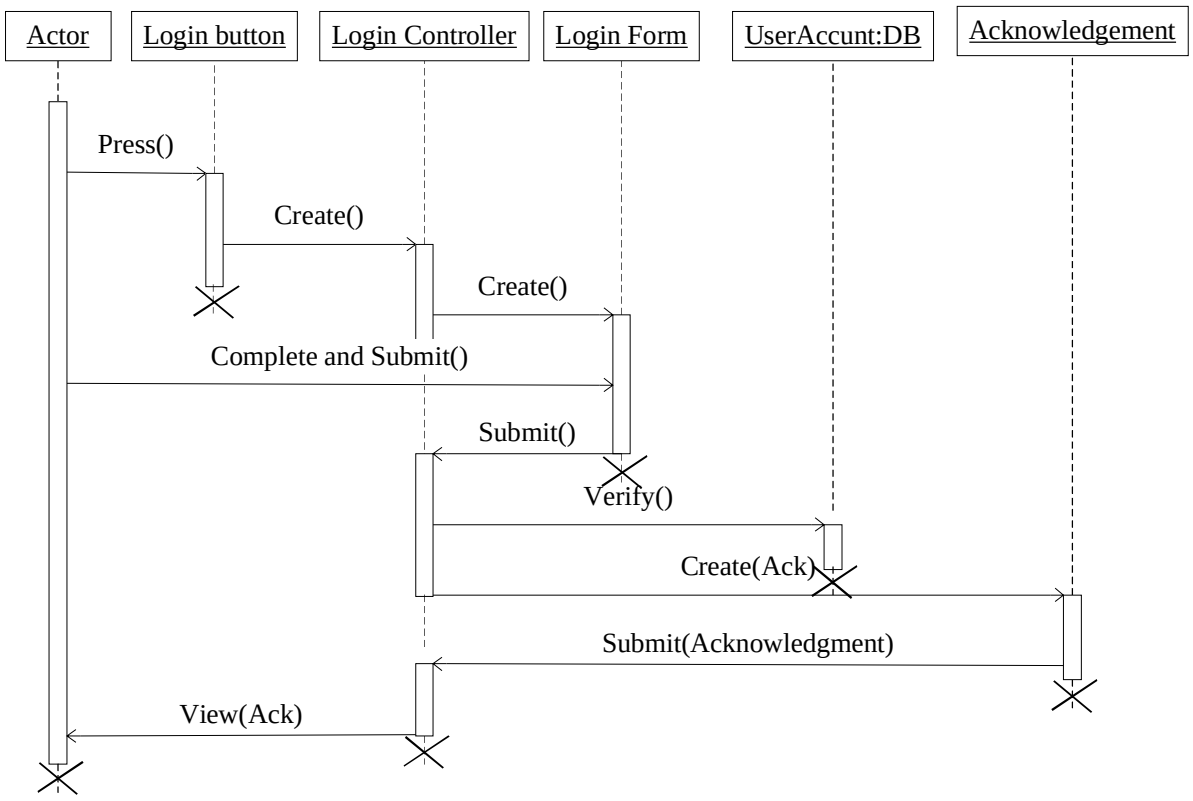

Figure 1: Sequence diagram for LogIn

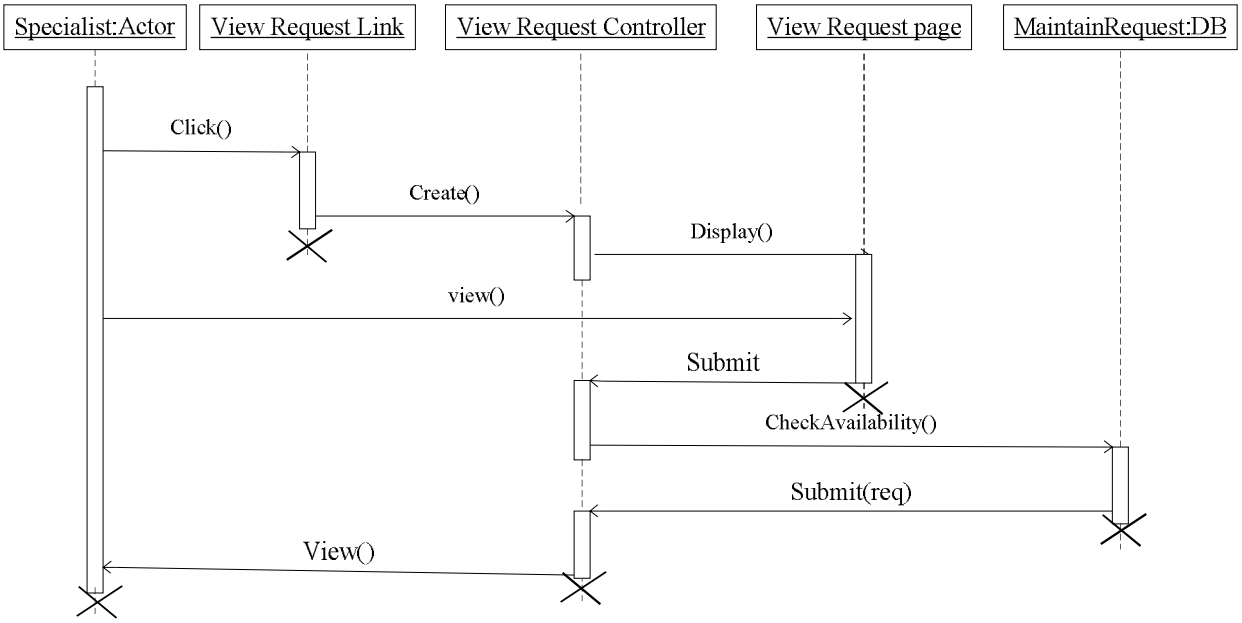

Figure 2: Sequence diagram for view disease information

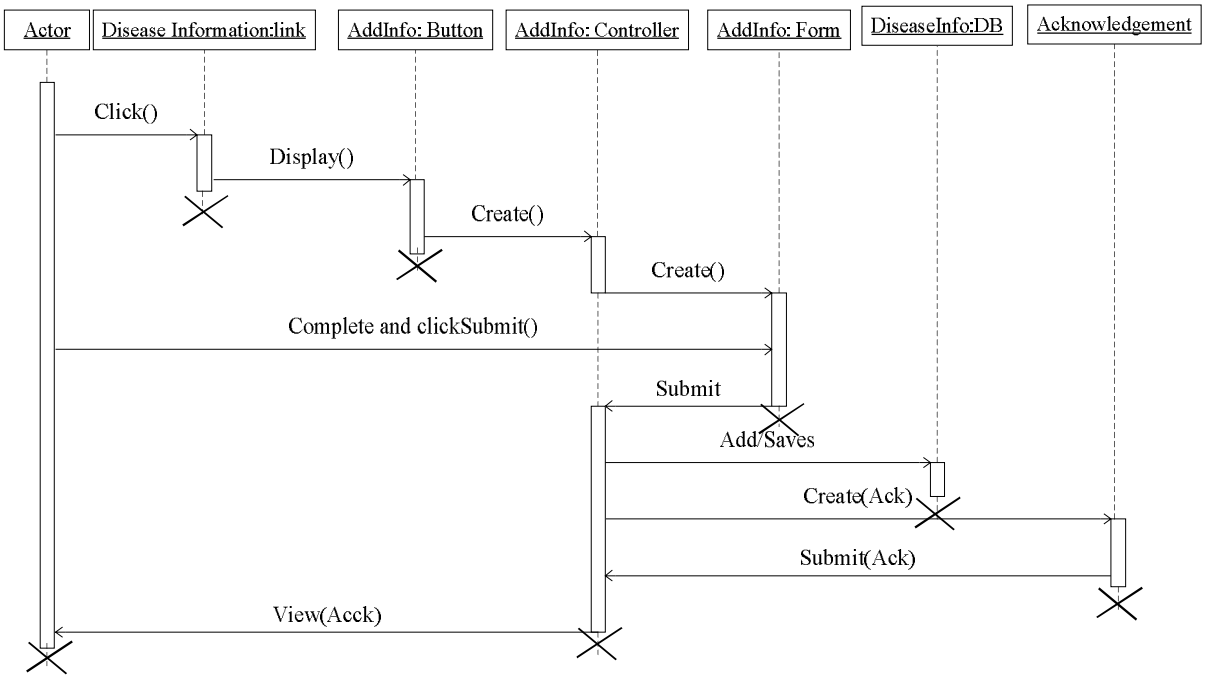

Figure 3: Sequence diagram for Add disease Information

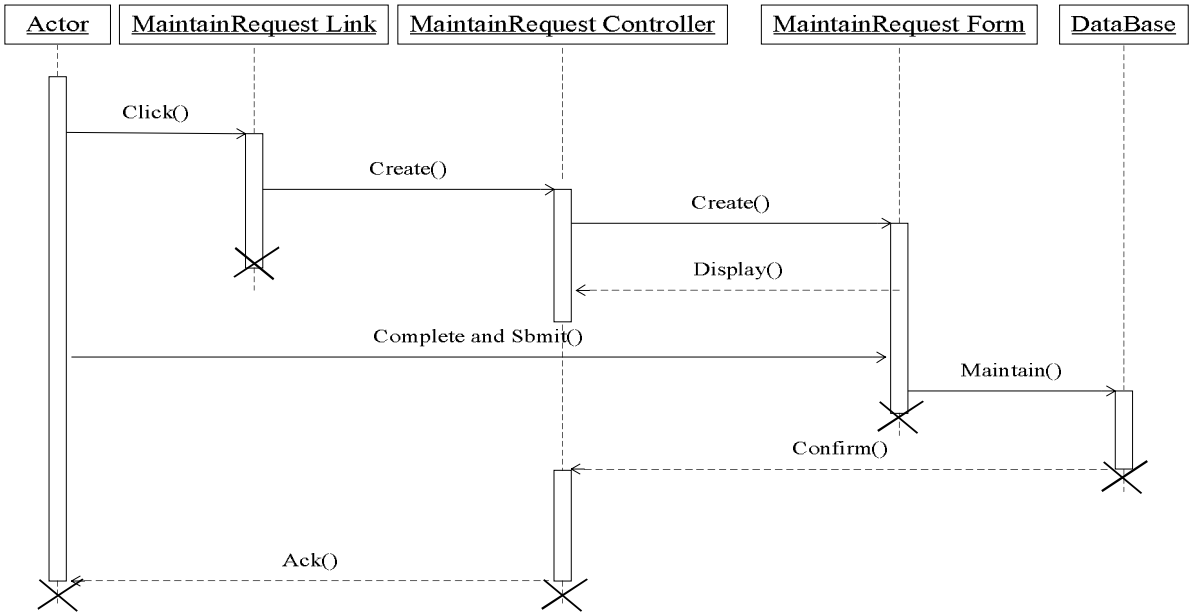

Figure 4: Sequence diagram for maintain request

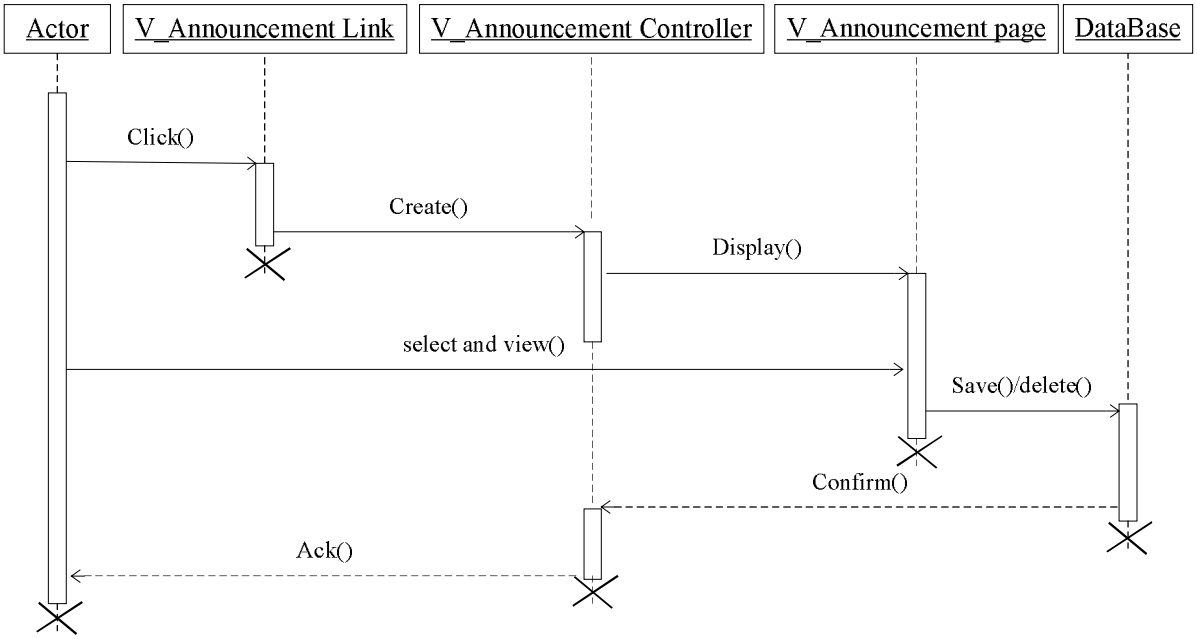

Figure 5: Sequence diagram for View Announcement

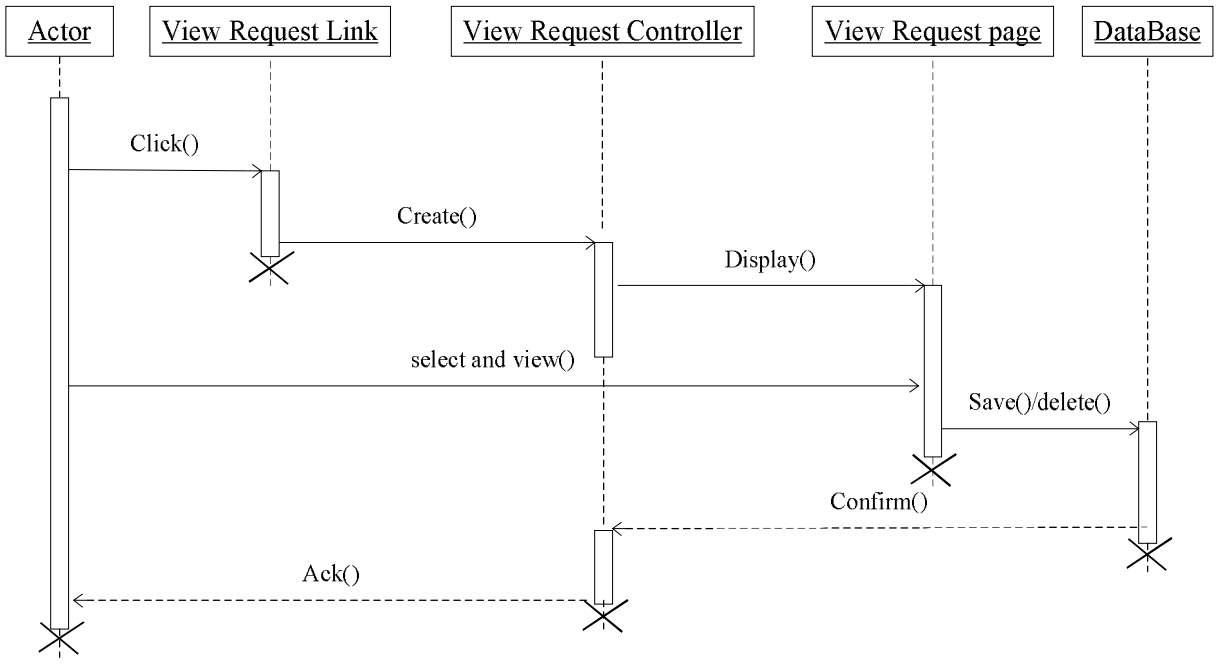

Figure 6: Sequence diagram for view Request

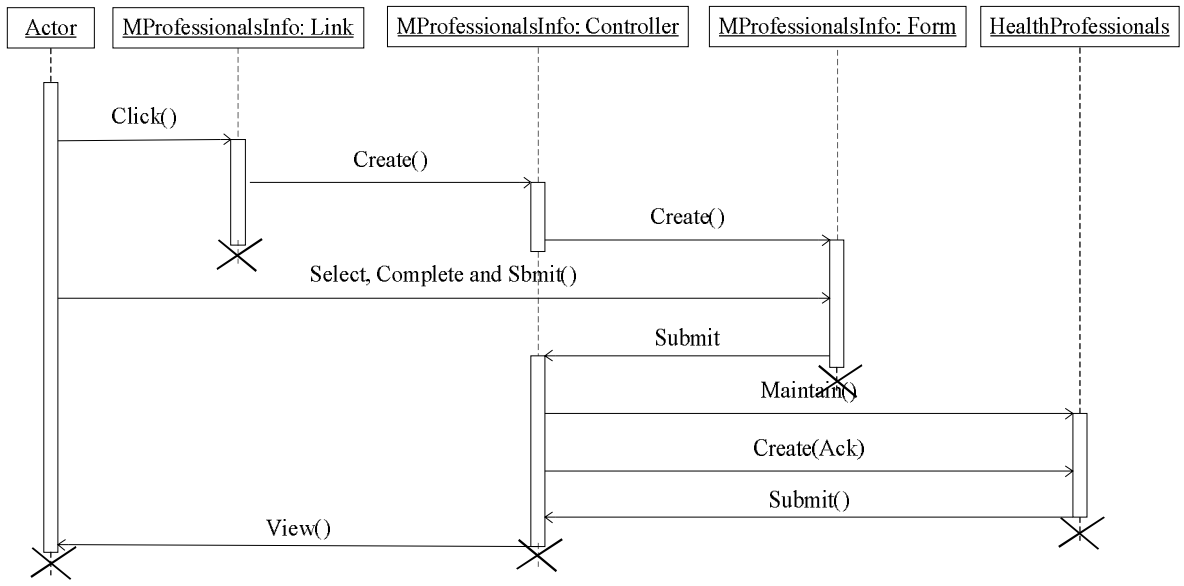

Figure 7: Sequence diagram for maintain Health professional profile

Annex B: Questionnaires

Addis Ababa University

College of Natural Sciences

Department of Computer Science, Postgraduate Program

Questionnaire to be completed by both health stakeholders and ethio telecom Managers

Introduction

Following the advancement of computing technologies, health systems of countries need to use computing technologies more effectively as a means of improving quality of health provision in all directions. The use of computing technologies in health domain for different applications including health education for health professionals and patients, remote consultation, remote monitoring, etc., is said to be telehealth or telemedicine. Telehealth is utilized by both health professionals and patients.

The purpose of this questionnaire is to explore the different issues related to the use of computing technology and the delivery of telehealth applications in the health sector of the country. The reason to do this is to develop a **Wireless Telehealth Support System in Ethiopia**. By completing this questionnaire, you can play a role to support our effort in introducing telehealth to the health sector of our country. We also would like to assure you that the response will be kept confidential and it will only be used for academic purposes.

Directions:

- ✓ No need to write your name
- ✓ Answer by putting a tick mark "√" in the box or by writing in the space provided.
- ✓ In case you have ambiguities on any of the questions, please do not hesitate to contact us through the address mentioned at the end of this questionnaire.

Part I: Personal Information

1. Sex: Male ☐ Female ☐
2. Age: 20-30 ☐ 30-40 ☐ 40-50 ☐ above 50 ☐
3. Organization's name _____
4. Profession _____
5. Specialization (if any) _____
6. Organizational Position: _____

Part II Questions on computing technology in the health sector or Telehealth Experience

1. Do you have any experience of using computing technologies (like Wireless networks, PDAs, and others) in the health sector of our country?

   Yes ☐ No ☐

1.1. If yes: For what purpose do you use the computing technologies?

To record patient visits, and/or schedules, and/or appointments. ☐

For Administration and finance routines ☐

To store and retrieve electronic patient information ☐

For file and printer sharing ☐

For database access ☐

E-mail ☐

Search electronic documents ☐

Others (please specify)

_____

_____

2. Do you have any experience of using wireless technologies to communicate with other hospitals (including remote hospitals), or specialists in other hospitals both in Ethiopia and abroad?

Yes ☐ No ☐

If Yes: In the same hospital ☐ in the same town ☐ country wide ☐ abroad ☐

2.1. If Yes for Q2, what was the main purpose of communication?

Medical consultation or Medical support (both professional to professional and patient to professionals) ☐

To handle patient case without face to face encounter with the patient ☐

To provide information about the patient such as lab results, x-ray, etc. ☐

Referral ☐

Exchange of Information ☐

Others (please specify)

_____

_____

2.2. What communication means were used for such communication? (You can tick more than one)

Telephone ☐ postal service ☐ email ☐ video and audio conferencing ☐

Web based applications ☐ hand-held PCs ☐ large flat displays ☐ Sensors ☐

Others (please specify)

_____

_____

2.3 If yes for Q2, which specific area of telehealth applications would be interested? (You can tick more than one)

Health education on disease prevention and management ☐ Dermatology ☐

Diabetic patient management ☐ Tele-consulting ☐

General practice / family practice ☐ tele-monitoring ☐

Infectious Disease ☐ Neurology ☐

Ophthalmology ☐ Radiology ☐

Others (please specify)

_____

_____

3. What do you think of a possible Wireless Telehealth Support System, which aims to achieve holistic change in health domain/sector?

I think it is good to deliver clinical care to remote areas ☐

I think it is good to improve quality of care in the urban areas ☐

I think it is good to deliver health education both for health professionals and patients ☐

I think it is too far to achieve. ☐

Others (please specify)

_____

_____

5. What factors do you think obstruct the development of wireless telehealth system in our country?

Cost of advanced electronic medical instruments and computers ☐

ICT awareness and skill of employees ☐

Medical Ethics ☐

Medico Legal issues ☐

Culture ☐

Others (please specify)

_____

_____

6. Would your organization consider applying a Wireless Telehealth Support System if it can be implemented?

Strongly agree ☐

Agree ☐

Uncertain ☐

Disagree ☐

Strongly disagree ☐

7. How do you think, you would benefit from a telehealth system?

_____

_____

Thank you for spending your precious time to complete this questionnaire. If you would like to contribute further to our thinking by discussing your views with us please complete your contact details below. We would be pleased to have a more detailed discussion with you through an interview.

Name: _____ Telephone: _____

Contact Person: Tsegaynesh Mogose

A Postgraduate student, Department of Computer Science

Addis Ababa University

Telephone: +251938048697/+251915442728,

Email: mogatsega@gmail.com

Annex C: User Manual

The main purpose of this user manual is to describe how the system works for the end users of the system since the telehealth support system is deployed.

1. Maintain Request

1.1 Web Interfaces

Send a Request

To send a request for different telehealth services in telehealth support system, after you start the system click the “maintain_request” button from the given list of application and accept the information about maintain request by clicking on “ok” button.

Figure 1: home page with Maintain request button

After you click on OK button the following Maintaining Request page will be displayed with a number of fields and with the operation for registration, update, and delete. Then you fill all the fields with necessary information and click “Register” button before sending the request.

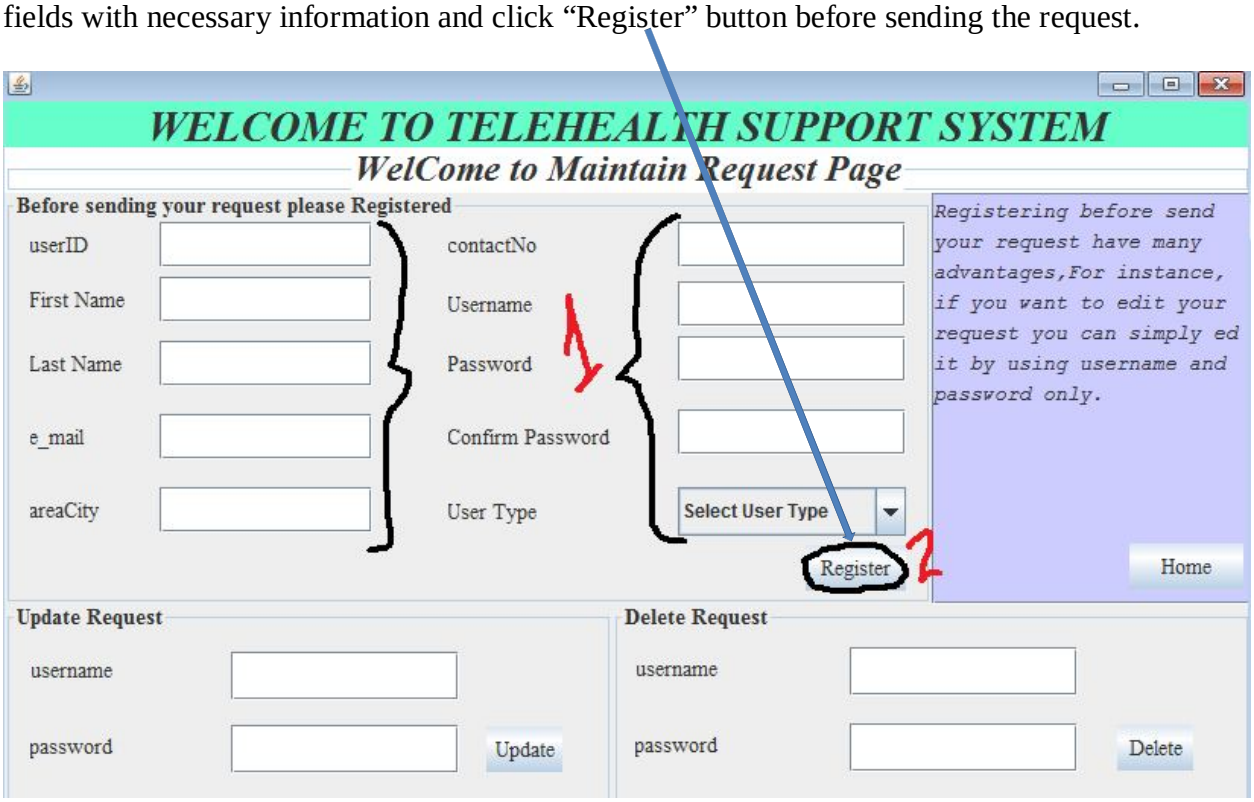

Figure2: Register to requesting

Then after you finish the registration, you information would be stored in the database for the future use, for example when you want to update and/ or delete your previous request you asked to enter username and password.

Delete request

If you want to delete your previous request do the following steps: First click on “maintain request”, insert the username and password that you use when you registered for the request. Next to this, after you give the correct username and password your previous request will be display. Finally you click on “Delete” button.

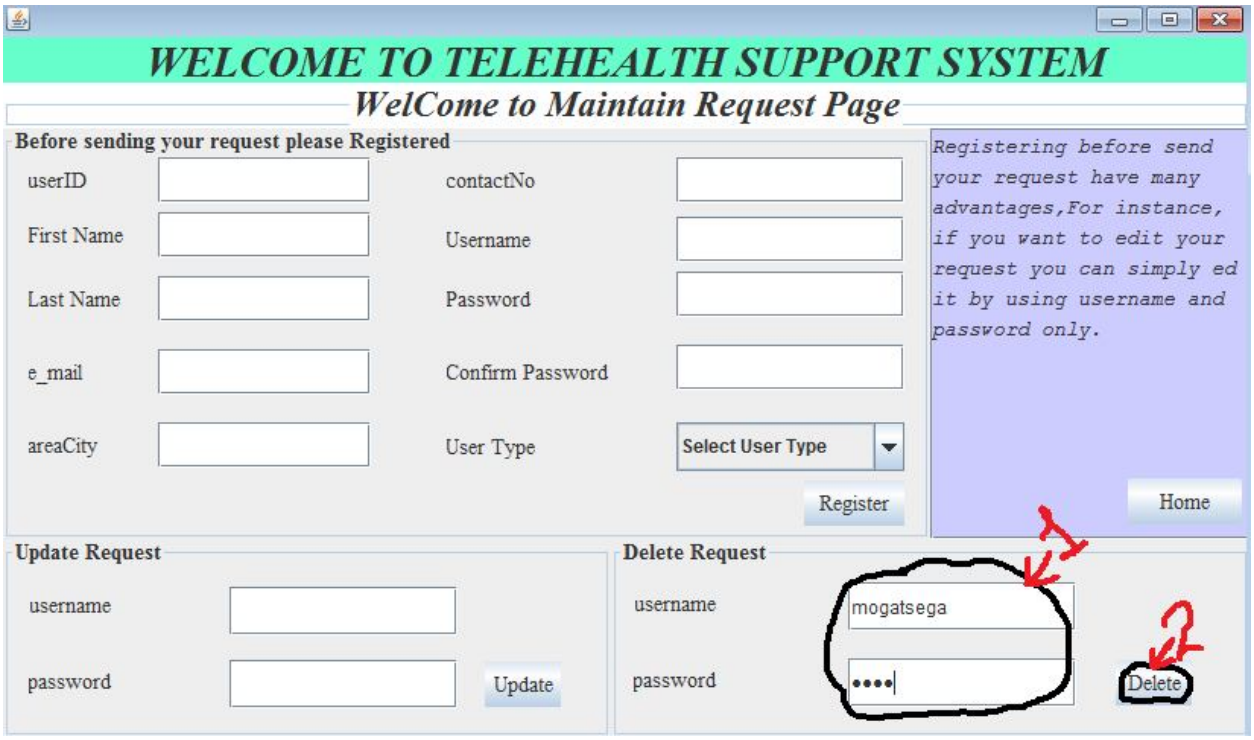

Figure 3: Delete request

Update Request

If you want to update your request that you done before, perform the following steps: First click on “maintain request” button from the home page and you proceed to maintain request page, then first you insert the username and password that you use at registration time of requesting. Since you insert correct username and password your previous request will be display. Finally you make your edition and click on “Update” button as shown in Figure 4.

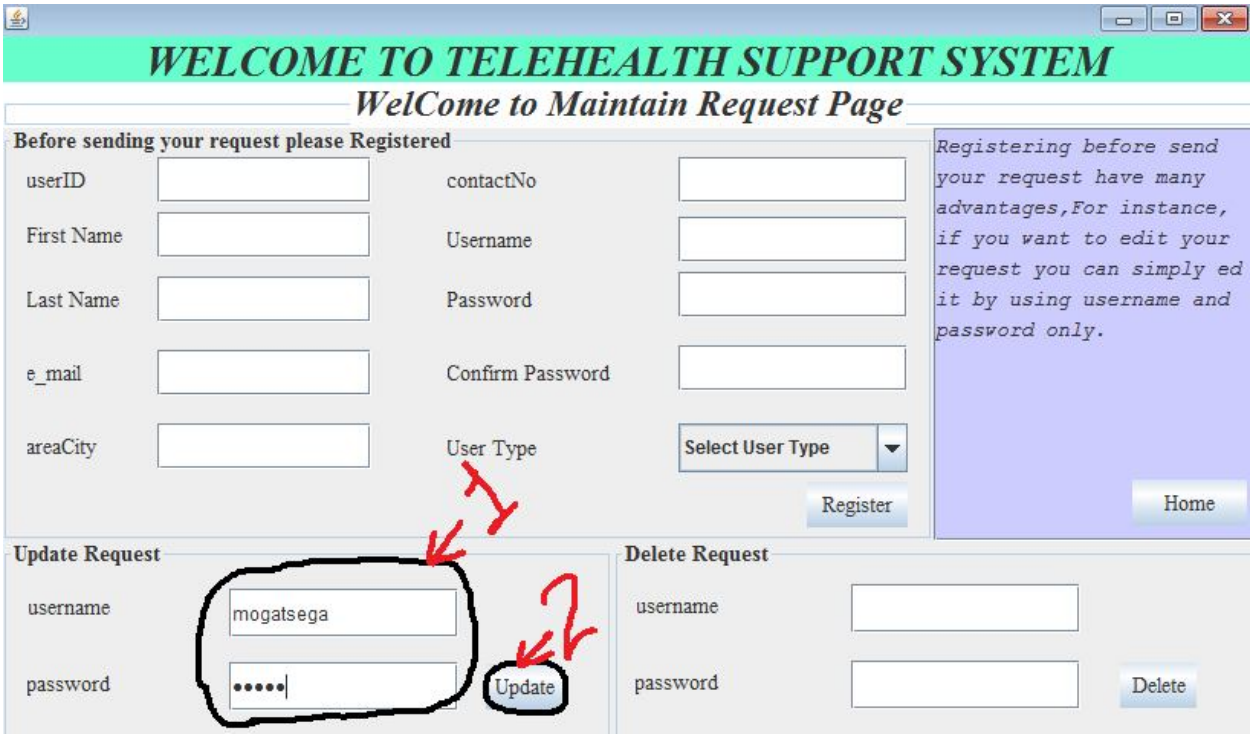

Figure 4: Update request

1.2 Mobile Interfaces

Send a Request

To send a request for different telehealth services in telehealth support system, after you start the system click the “maintain_request” button from the given list of application. Clicks on “Done” button that found next to left side navigator key of mobile phone and accept the alert that informs you to register for maintaining request.

Figure 5: home page with Maintain request button

After you click on "Done" button the Registration form will be displayed with a number of fields and the request. Then you fill all the fields with necessary information and click "Register" button before sending the request. After you do this, the following registration form will be displayed with a number of fields (that represented by number 1) that asks you for inserting detail information about you as well as with an operations like register, update, and delete (you

can found these by click on “menu” button). Next, click on Menu (number 2) button and select “Register” operation

Figure 6: Registration form with registration option

Delete request

If you want to delete your previous request do the following steps: First click on “maintain request”, insert the username and password that you use when you registered for the request. Next to this, after you give the correct username and password your previous request will be display. Finally you click on “Delete” button.

Figure 7: Delete request

Update Request

If you want to update your request that you done before, the steps are similar to delete request, the difference is that from the list of operation select “Update” instead of “Delete”. Finally you make your edition and click on “Update” button.

2. Maintain Disease Information

In order to maintain disease information first of all you must be health professional and login to the system as a health professionals. To do this, since you click on “maintain disease information” button, as shown in number 1 of Figure8, the system displays the login form as you see in Figure9.

Figure 8: Maintain Disease Information button

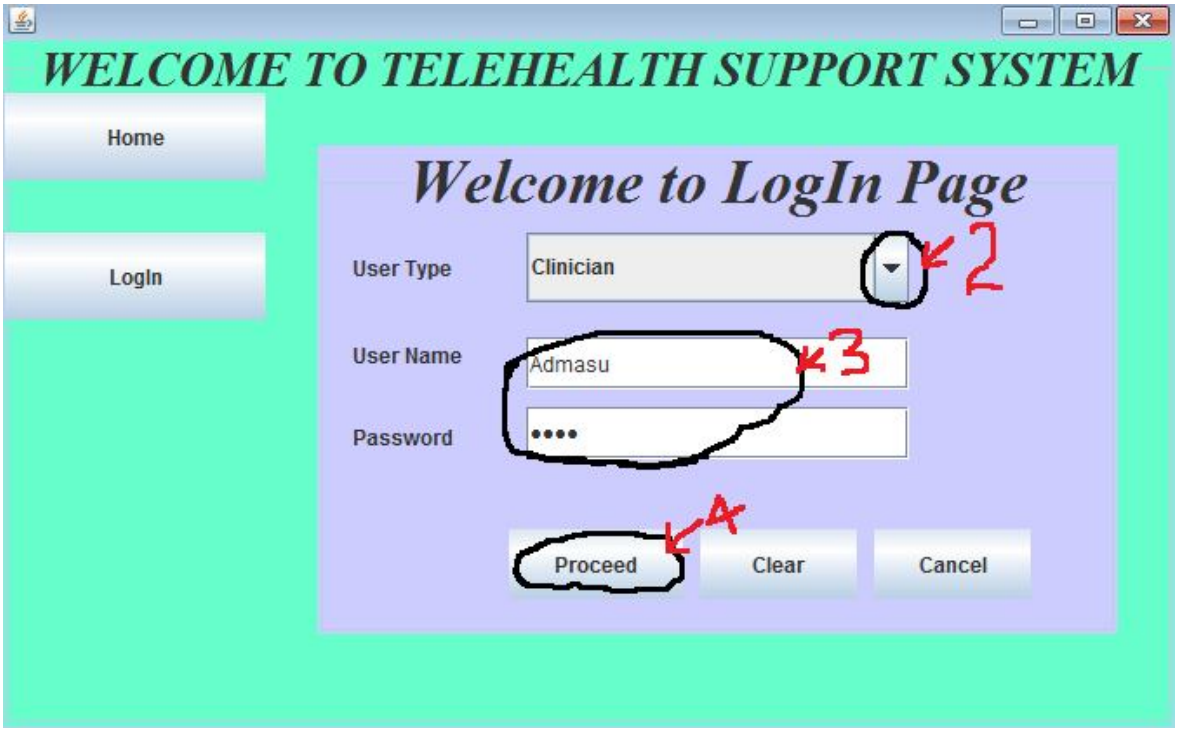

Figure 9: Login to the system as health professional

After you login to the system as a health professional, first you fill the fields with relevant information and click on "Add" button.

Figure 10: Add Disease Information

Declaration

I, the undersigned, declare that this thesis is my original work. It has not been presented for a degree in any other university, and that all source of materials used for the thesis have been properly acknowledged.

Declared by:

Name: Tsegaynesh Mogose Lefebo

Signature: _____

Date: _____

Confirmed by Advisor:

Name: Dr. Mulugeta Libsie

Signature: _____

Date: _____

Place and date of submission: Addis Ababa, February 2015